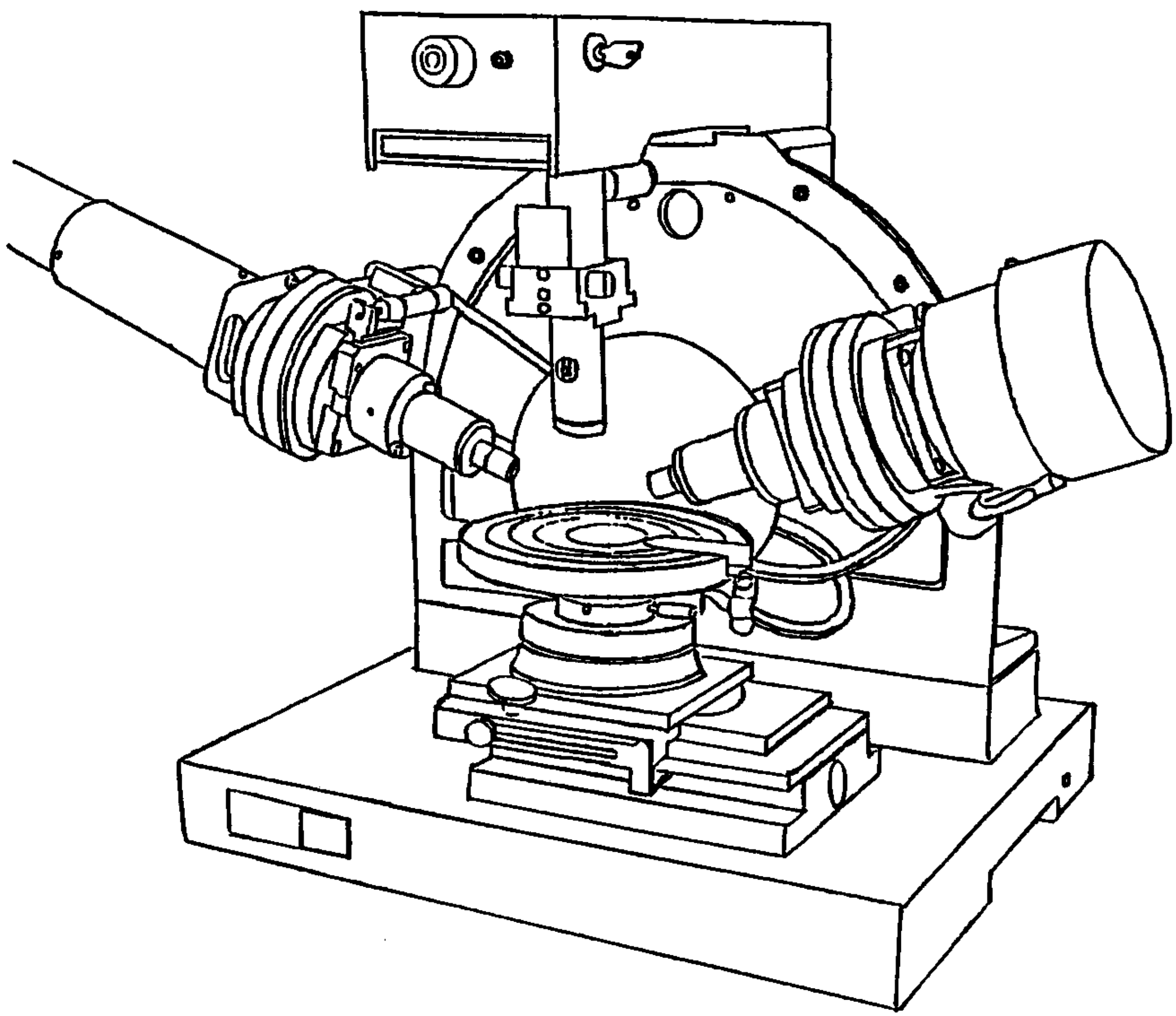
USER MANUAL

MODEL L116S ELLIPSOMETER



GAERTNER SCIENTIFIC CORPORATION

1201 West Wrightwood Avenue, Chicago, IL 60614

7109-C-229S

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF FIGURES

TABLE

WARRANTY

ALL OF THE OPTICAL, MECHANICAL AND ELECTRICAL COMPONENTS OF THE GAERTNER ELLIPSOMETERS, INCLUDING THE LASERS, ARE WARRANTED FOR ONE YEAR FROM THE DATE OF DELIVERY. ANY DEFECTS IN MATERIAL OR WORKMANSHIP WILL BE CORRECTED BY GAERTNER AT NO COST. SHIPPING CHARGES, TRAVEL AND LODGING COSTS INCURRED BY THE SERVICE PERSONNEL ARE NOT COVERED BY THIS WARRANTY. WARRANTIES ON DEFECTS IN MATERIAL OR WORKMANSHIP FOR COMPUTER EQUIPMENT SUPPLIED WITH THE L116S ELLIPSOMETER IS WARRANTED BY THE COMPUTER MANUFACTURER AND THEIR STANDARD WARRANTY CONDITIONS APPLY. THE COMPUTER MANUFACTURER WILL, AT THEIR OPTION, REPAIR OR REPLACE EQUIPMENT THAT PROVES DEFECTIVE DURING THE WARRANTY PERIOD. REPAIRS THAT ARE NECESSITATED BY THE MISUSE OF THE EQUIPMENT, INCLUDING THE USE OF SOFTWARE OR INTERFACING NOT SUPPLIED BY GAERTNER, ARE NOT COVERED BY THIS WARRANTY. NO OTHER WARRANTY IS EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, IMPLIED WARRANTY OF MERCHANTABILITY AND SUITABILITY FOR A PARTICULAR PURPOSE. GAERTNER SHALL NOT BE LIABLE FOR CONSEQUENTIAL DAMAGES.

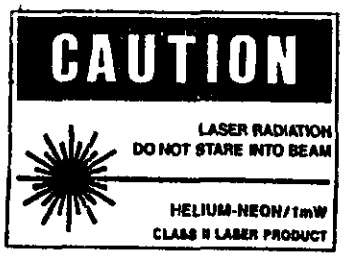
LASER SAFETY

GOVERNING REGULATION

The Gaertner ellipsometer utilizes a helium-neon laser light source. The accessible radiation does not exceed one milliwatt and, therefore, is classified as a Class II laser product as defined by Radiation Performance Standards 21CFR, Subchapter J (Federal Register, Volume 10 #148, July 31, 1975). Appropriate WARNING and Conformance labels are affixed to the ellipsometer to alert personnel of the presence of laser radiation during operation.

WARNING
Logotype

Attached to the polarizer arm and reads: LASER RADIATION. DO NOT STARE INTO BEAM.



APERTURE
Label

Attached to the exit aperture of the polarizer module and reads:
AVOID EXPOSURE. LASER RADIATION IS EMITTED FROM THIS APERTURE.



CERTIFICATION
Label
(Not Shown)

Attached to the left front face of the vertical plate and reads:
THIS LASER COMPLIES WITH DHEW/CDRH RADIATION PERFORMANCE STANDARDS 21CFR SUBCHAPTER J.

CAUTION

Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

1.0 SPECIFICATIONS

Net Weight (approx.)	30 kg (65 lbs)
Shipping Weight	43 kg (95 lbs)
Dimensions (approx.)	
Height	45.7 cm
Width	83.8 cm
Depth	38.0 cm
Laser Light Source (less than 1 mW accessible radiation)	632.8 nm Helium-Neon (Red)
Incidence Angles Detented	50° and 70° are used the most. See the next page.
Beam Diameter Standard 1 mm**	1.0 x 1.6 mm at 50° 1.0 x 3.0 mm at 70°
Polarizer Drum	360° graduated at 1° intervals with 10-part venier (0° to 1°)
Sample Size	Up to 150 mm (5.9") diameter and 10 mm thick
Method of Measurement	Four detector-voltages are used to determine state-of-polarization of light of reflected beam. The surface parameters *Psi* and *Delta*, and hence film thickness and index of refraction, are calculated.
Film Thickness Range	0 to 60,000 Angstroms (0 to 6,000 nm)
Accuracy	±3 Angstroms (±0.3 nm)*
Repeatability	±1 Angstrom (±0.1 nm)*
Refractive Index	±0.005*
Line Voltage	115V ac (50-60Hz) std.; 100V ac, 200V ac, 230V ac or 240V ac available.
Standard Program	See Section 3 of this manual.
Optional Programs	See Section 4 of this manual.

*Over most of the measurement range.
**See the *next page for all of the* detented angles. There is also 90°, but that is only for adjustments.

1.0 SPECIFICTIONS (Continued)

This ellipsometer has the detented angles of incidence in the table below for measurement purposes. There are also detents for 90°, but this angle is only for adjustments.

ϕ	Standard Beam on Sample	Microspots* Beam on Sample
30°	1 mm x 1.15 mm	15 µm x 17.2 µm
45°	1 mm x 1.41 mm	15 µm x 21.1 µm
50°	1 mm x 1.55 mm	15 µm x 23.2 µm
55°	1 mm x 1.74 mm	15 µm x 26.0 µm
60°	1 mm x 2.00 mm	15 µm x 30.0 µm
65°	1 mm x 2.37 mm	15 µm x 35.5 µm
70°	1 mm x 2.92 mm	15 µm x 43.8 µm
75°	1 mm x 3.86 mm	15 µm x 57.9 µm
80°	1 mm x 5.76 mm	15 µm x 86.3 µm

*The Microspot Optics are optional components for the polarizer and analyzer arms. See "Optional Components", section 6.

Table 1-1 Standard and Microspot beam dimensions on the sample wafer.

2.0 ABBREVIATIONS AND SYMBOLS

N_f	Real value of refractive index for film being measured
K_f	Extinction value of refractive index for film being measured
N_s	Real value of refractive index for substrate
K_s	Extinction value of refractive index for substrate
Φ	(PHI) Angle of incidence
Ψ	(PSI) Amplitude ratio as determined by measurement
Δ	(DELTA) Phase difference as determined by measurement
A/D	Analog-to-digital
ADJ	Adjust
AMPL	Amplifier
AS	Autoset
A/AUTO	Automatic
cm	Centimeter
CTL	Control
DET	Detector
M/MAN	Manual
mm	Millimeter
nm	Nanometer
PCTL	Peripheral Control
PD	Photodetector
PFLG	Peripheral flag
P/O	Part of
PWR	Power
RECT	Rectifier
REF	Reference
SM	StokesMeter
SOP	State-Of-Polarization
SPLY	Supply
STD	Standard
SW	Switch
W/O	Without

3.0 INTRODUCTION

This section describes the components of this ellipsometer and shows how the ellipsometer analyzes the effect of reflection on the polarization of the laser light striking the surface of materials, such as bare substrates, to acquire measurement data identifying properties critical to quality control. Interpretation of the data yields the optical constants of the material or, if the material surface is film-covered, the thickness and optical constants of the film. Once initiated by the user, analysis and measurement are automatic, utilizing a programmed, desktop computer interfaced with the ellipsometer. Parameters are entered by the user via the computer keyboard. Queries requiring operator/computer interaction and actual measurement data are displayed on the computer screen. Measurement data may be printed for a permanent record. Optional equipment is in the Optional Components section.

4.0 OPTICAL SYSTEM (Reference Figure 1-1)

Ellipsometric measurements involve illuminating the surface of a sample wafer with monochromatic light of a known wavelength and polarization and then analyzing the polarization of the reflected light. The light is projected along a fixed path or angle of incidence (ϕ). This ellipsometer has provisions for precise, pin-located settings of the angle of incidence at 30°, 45°, 50°, 55°, 60°, 65°, 70°, 75°, 80° or 90°.

For measurement purposes, the angle of reflection is always set at the same angle as the angle of incidence. (Since the two angles are always equal, it is usual to refer to both angles as angles of incidence.) With the angles properly set, their respective optical axes intersect the vertical center line of the plane of incidence at the same point. The sample table is raised or lowered so that the intersection of the incidence and reflective optical axes occurs on the sample surface, and that the sample surface is normal to the vertical centerline of the plane of incidence. This ensures that the light from the polarizer aperture is reflected from the sample surface into the analyzer aperture.

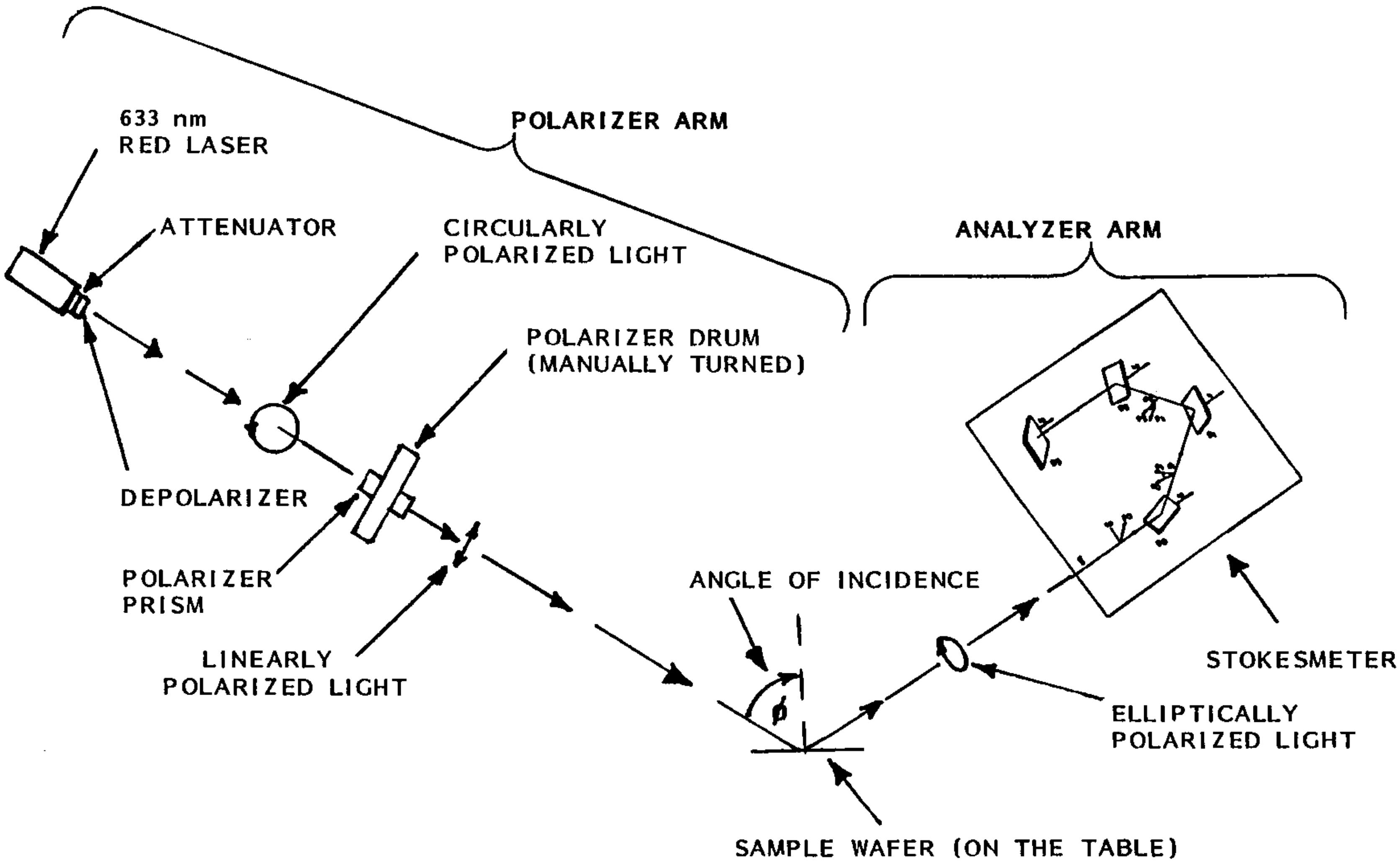


Figure 1-1 This is the Optical System Functional Diagram for a single-wavelength ellipsometer.

4.0 OPTICAL SYSTEM (Continued)

A low-power (Class II) laser-light source is employed; a helium-neon laser having a beam wavelength of 632.8 nm. The 632.8 nm (red) laser is in the line of the optical axis, and the beam passes through a polarizer prism. In passing through this prism, the beam polarization is converted from circular to linear.

The reflected light, with its polarization altered by the optical properties of the sample, is captured by the Stokesmeter (SM) measurement head. The four detector-voltages of the Stokesmeter are then computer-analyzed and converted into a measurement of the State-of-Polarization (SOP) of light of the reflected light.

5.0 ELLIPSOMETER COMPONENTS

The main components of the single-wavelength L116S ellipsometer are shown in Figure 1-2.

5.1 Laser Assemblies

A red laser, with a fixed wavelength of 632.8 nm, has an attenuator that reduces the laser power to Class II, which is for under one milliwatt. A built-in quarter-wave depolarizer in the laser output produces a circular polarization of the beam.

NOTE: When the beam attenuator (subsection 5.2) is pulled out, the laser beam strikes the sample wafer or table surface, both the polarizer and analyzer arms must be at the same angle of incidence. Then the ellipsometer can make measurements and will be safe to work with.

5.2 Polarizer (Reference Figures 1-1 and 1-2)

Polarizer Drum and Prism. The polarizer prism, mounted in the polarizer drum, is a Glan Thompson calcite prism that converts the circularly polarized light from the laser to linearly-polarized light. Any given angle of prism orientation from 0° to 360° can be set by adjusting the polarizer drum. The angle can be set to within tenths of a degree by setting a number in whole degrees (indicated on the drum) just below zero (0) on the 0-to-1 vernier scale and then aligning a graduation on the vernier scale to one on the drum scale. For automatic measurements, the user should fix the polarizer drum at exactly 20° by inserting the locking screw into the drum's detent.

5.0 ELLIPSOMETER COMPONENTS (Continued)

5.2 Polarizer (Reference Figures 1-1 and 1-2)

Beam Attenuator. The beam attenuator (more correctly called a "beam blocker") lever, at the polarizer module output aperture, is a manually-operated slide device to either block the incident beam or to allow passage of the beam to the sample surface.

5.3 Sample Monitor Assembly

The Sample Monitor Assembly has a combination tilt monitor and 39-power, sample surface-viewing scope. Using the viewing scope function, the operator can examine the sample surface for damage or imperfections. The light source for the surface illumination is built-in, originating within the sample monitor assembly enclosed in a housing above the objective end of the sample monitor. The intensity of illumination is variable by the rotation of a control on the left side of the Sample Monitor Assembly.

Using the tilt monitor function, the operator can detect an out-of-flatness condition of the sample surface and compensate for this condition. The amount of out-of-flatness is determined by observing a reflected image projected as background on 90-degree crosshairs in the eyepiece. Compensation is accomplished by tilt adjustment of the sample table in X and Y planes. The tilt adjustment controls are just under the table. See the Operation section.

The Sample Monitor Assembly includes the following:

- Emission indicator
- Electrical Control Group:
  - Key-operated ellipsometer and laser power (ON/OFF) switch
  - Sample illumination control

5.4 Reference Sample

A silicon substrate wafer reference sample with a single-layer silicon oxide film (thickness of about 780Å or 78nm) is supplied with the ellipsometer. Initially, the sample should be used to obtain sample measurements in the process of instrument familiarization. Periodically, the sample should be used to obtain measurement data for comparison with previous data to verify that the ellipsometer is in proper adjustment.

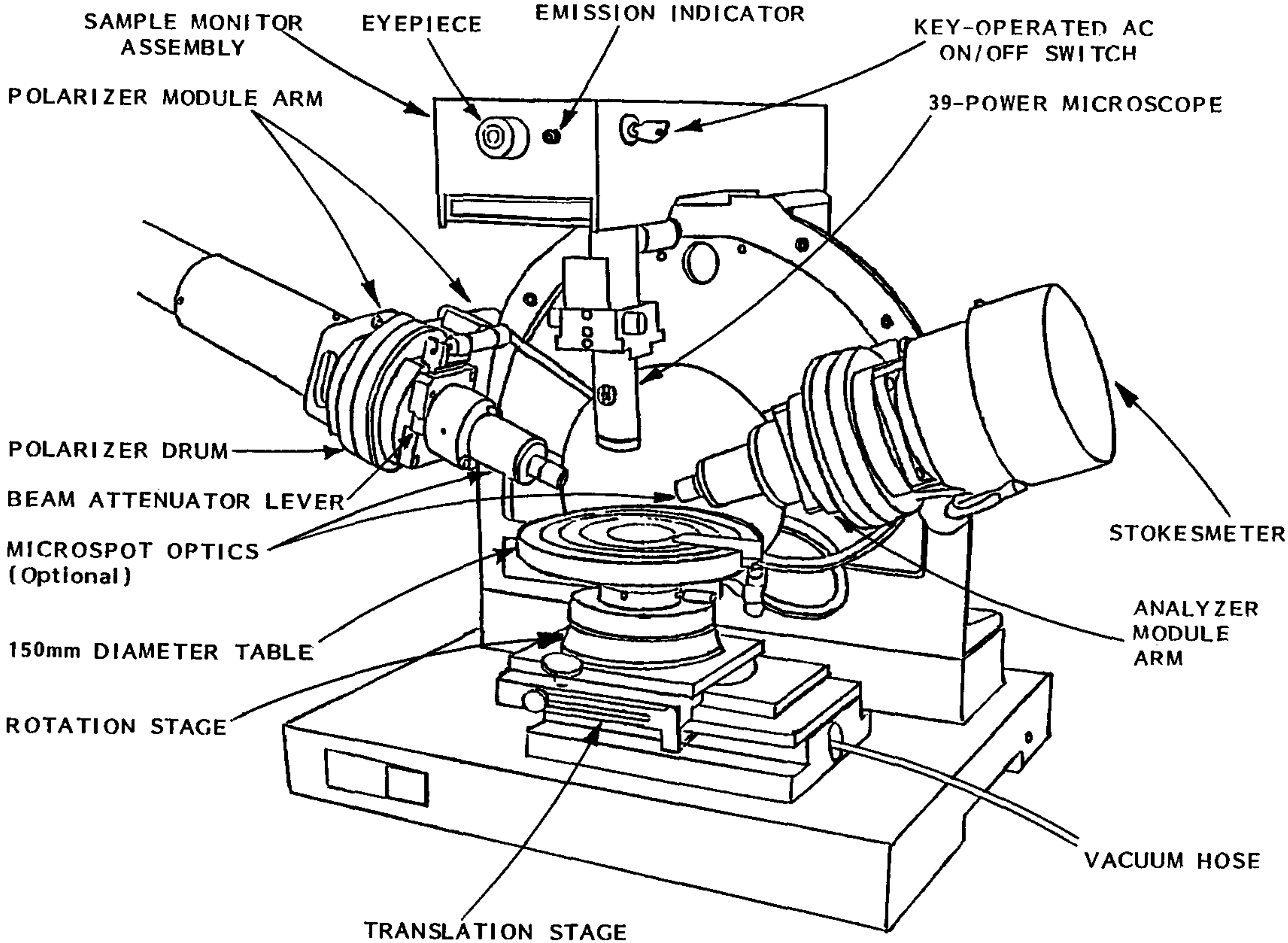


Figure 1-2 Front-view components of the L116S Ellipsometer.

5.5 Analyzer Module

StokesMeter Measurement Head. The SM is a four-detector-photopolarimeter consisting of four specularly reflecting photodetectors which intercept the incident light at oblique angles of incident. The electrical signals of the four detectors are computer-analyzed to determine completely the SOP of the incident light in terms of the Stokes parameters.

5.6 Electronic Chassis

This assembly is in the ellipsometer base; it consists of sample and hold circuitry, autoranging gain circuitry, and computer interfaces.

5.7 Instrument Power Supply

This assembly is in the vertical enclosure, at the rear of the support frame. The power supply provides the conversion of various line voltages, compensator control and laser drive.

5.8 Sample Stage and Table

The sample stage provides a combination rotary and linear manual positioning of the sample table, allowing measurement at any point on the sample surface. This is achieved by linear translation in the (+) X direction from center and rotation from 0° to 360°. The linear scale is graduated in one (1) mm increments, numbered at 10 mm intervals from 0 to 75 mm full scale. The rotary scale is graduated in 1° increments, numbered at 10° intervals from 0° to 360°. See Figure 1-2 on page 1-10.

The table is vertically adjustable, so that the laser beam reflected from the sample surface is maximized when entering the analyzer aperture. The vertical position is adjusted by rotating a knurled knob on the support structure. (A clockwise rotation raises the table.) A locking screw secures the vertical adjustment.

The standard table will accept samples up to 150 mm (5.9") in diameter, and is tiltable up to one (1) degree in both X and Y planes from the predetermined level position established at Gaertner just before the shipment of the ellipsometer. See the description of the Sample Monitor Assembly (page 1-9). A fine-motion vertical position adjustment option may be added to the table. An attachment for the vacuum pump is on the right side of the stages. See Figure 1-2 on page 1-10.

Yellow plastic locator strips are supplied for use in centering a wafer sample on the table surface. For example: A plastic strip can be inserted into either the 3-inch, 100 mm, 125 mm or 150 mm diameter groove in the surface of the standard table.

6.0 DETERMINATION OF PSI AND DELTA

The state of polarization of the beam is determined by the relative amplitude (amplitude ratio) and the relative phase shift (phase difference) between the two component plane waves resolved from the electric field of the beam. If the phase difference between the components is either 0° or 180°, the beam is linearly polarized. All other phase differences result in elliptical polarization. When a monochromatic beam of polarized light strikes the surface of a sample, the reflection of the light causes a change in the relative phases of the component plane waves and a change in the ratio of their amplitudes.

The angle **DELTA (Δ) is defined as a phase difference. PSI (Ψ) is defined as the arctangent of the amplitude ratio.** The phase difference (Δ) and the amplitude ratio (Ψ) thus **characterize** the elliptically polarized light reflected from the sample surface. These parameters are used to calculate the optical constants of bare surfaces (or substrates) and, if film covered, the thickness and refractive index of the film. The refractive index (N_f) is used to determine the physical composition of the film and in the case of transparent films, to establish the magnitude of the period, i.e., the thickness cycle before ellipsometric readings repeat.

Using measurement data obtained from the four detectors of the StokesMeter, the computer calculates the Stokes parameters of the reflected light. This information, coupled with the known incident state-of-polarization, is used to determine the surface parameters, PSI and DELTA.

7.0 STANDARD PROGRAM DESCRIPTIONS

One standard single-point program (STDS) is supplied with each ellipsometer that has an IBM computer.

The Standard (Single-Point) Program, STD (S6S+S7S+G5S+SubS) is for both L115S and L116S Ellipsometers. There are four subprograms:

- G5S FILM: This subprogram determines the thickness and refractive index of a single-layer, transparent (nonabsorbing) film of silicon dioxide or silicon nitride on a silicon subtrate. Data Output: Thickness, index, PSI (Ψ), DEL (Δ), and the period. There is a fixed index option.
- S6S SPECIFIC: This is similar to the Film subprogram. Oxide or nitride films are evaluated at an incidence angle of only 70°.
- S7S TWO ANGLE: This subprogram measures the thickness of silicon oxide, silicon nitride or other nonabsorbing film on silicon substrate. Two-angle measurements are at 50° and 70° incidence angle. It determines the absolute thickness of thick films based on the order or period from a matched measurement at each angle. Data Output: Matched thickness values, index and a listing for each angle.
- SubS SUBSTRATE: This subprogram determines the optical constants of a bare substrate. These constants need to be known before making thin film measurements. Data Output: PSI (ψ), DEL (Δ), real (N_s) and extinction (K_s) refractive indexes of the substrate.

TABLE OF CONTENTS

1.0 PREMEASUREMENT SETUP

The premeasurement setup includes setting the polarizer and analyzer angles of incidence, the turn-on and the warmup of the ellipsometer, and initial alignment of the sample stage.

1.1 Setting the Angle of Incidence (See Figure 2-1, next page)

CAUTION

Do not grasp the 632.8 nm (red) laser when setting the polarizer arm. That may easily cause laser misalignment.

a. Grasp the polarizer arm (but never by the laser); and at the rear of the arm, loosen the clamp screw (Figure 2-1) about one turn.

b. Pull outward on spring-loaded locator pin next to the clamp screw, and move the arm to the 70° angle of incidence.

c. Release the locator pin, and move the arm slowly up or down until the pin seats in the detent on the vertical plate. Tighten the clamp screw. (This accurately sets the angle of incidence.)

d. Repeat steps a through c to set the analyzer arm angle of incidence, but do not apply pressure to the SM (StokesMeter) measurement head.

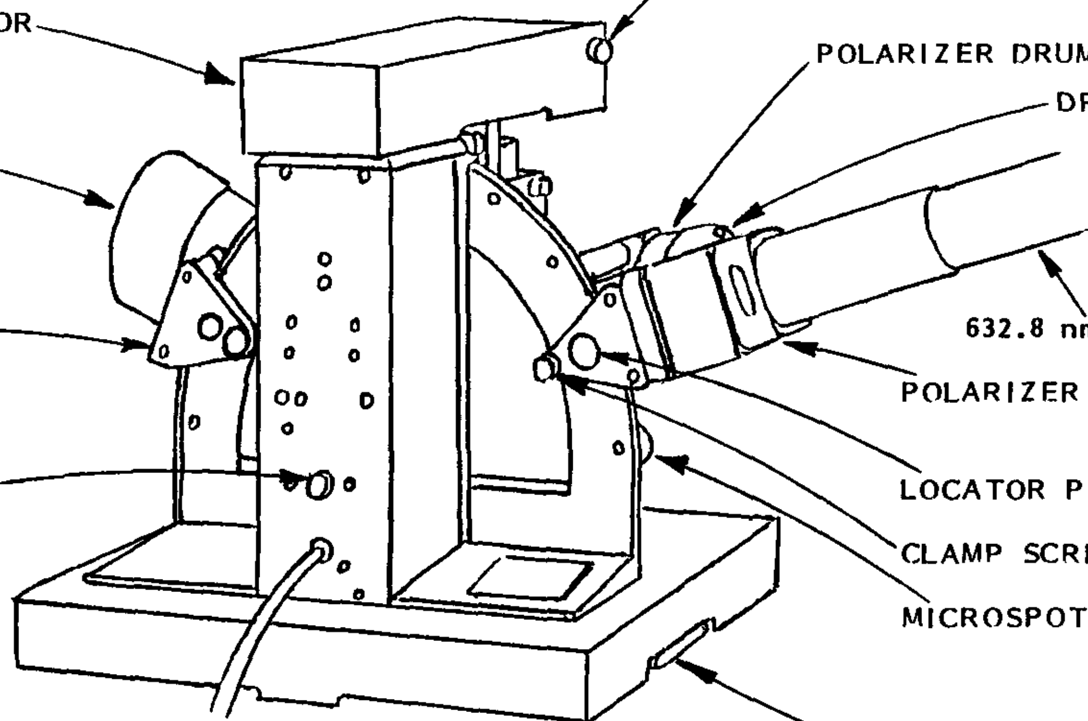
NOTE: Follow steps a to d also when setting the angle of incidence at any other detented angle.* The detented angles are 30° and 45° to 80° in 5° steps. There is also 90°, which is only for adjustments. See Table 1-1 in subsection 1.0 and Table 1-1 of the Description section about the detented angles.

e. Set the polarizer drum to 20°, and secure it by inserting the locking screw (Figure 2-1) in the hole on the side of the drum.

*See the *Caution* note at the top of Figure 2-1 about the arms with the optional Microspot optics at the 90° angle of incidence. *Note the statement (with the asterisk)* just above the caption about the fact that with microspots the arms cannot be set at 90° with the larger table.

CAUTION (For 90° Angle of Incidence)*

If the L116S has Microspot Optics, rotate the 150 mm table so that its lifting slot is under the analyzer Microspot. Move the table to the left and down so that neither Microspot Optic will contact the table when both of the arms are at 90°.



*The optional 200 mm diameter table cannot be moved out of the way of the optional Microspot Optics. Therefore the arms cannot be set at 90° with both of these options.

Figure 2-1 Rear and left view of the L116S Ellipsometer (with the standard table).

1.2 Turn-on and Warmup

a. Connect the ellipsometer and the computer according to the Installation Section.

b. To turn on the ellipsometer and the 632.8 nm (red) laser, turn the key-operated power switch on the Sample Monitor Assembly fully clockwise, ON (Figure 2-2, next page). The Emission Indicator lamp should illuminate. (Power is applied to the laser, which should be on.) A 15-minute minimum warmup of the 632.8 nm laser is recommended before performing ellipsometric measurements.

c. Pull to open the beam attenuator (Figure 1-2 in the Description section), and proceed with the following subsection.

1.3 Sample Table Vacuum and Alignment

Vacuum In the rear part of the table are small *(#0-80x1/8" round head,* stainless steel) plugs that can be removed when a vacuum pump is connected to the ellipsometer. Remove only the plugs that will be under the wafer, but not the plug under the *edge of the* wafer (see Figure 2-3).

Alignment Follow this procedure, beginning with step a.

a. With tweezers, *air wand, etc.,* put *a reference* sample or wafer with a single-layer, nonabsorbing film of a known thickness on the table via the insertion slot. Turn on the vacuum pump if it is connected to the table vacuum hose.

b. *Loosen the sample* table clamp screw.

c. *Look into* the Sample Monitor Assembly eyepiece, turn the sample illumination control for the desired illumination, and then adjust the eyepiece (by slightly pushing it in or pulling *out*) *for* the sharpest focus of the 90° crosshairs.

d. Rotate either one of the Sample Monitor Control knobs (in Figure 2-2) so that it brings a reflected image of the two diagonal lines into view (if not already in view), as seen through the eyepiece.

(section 1.3 continued on page 2-6)

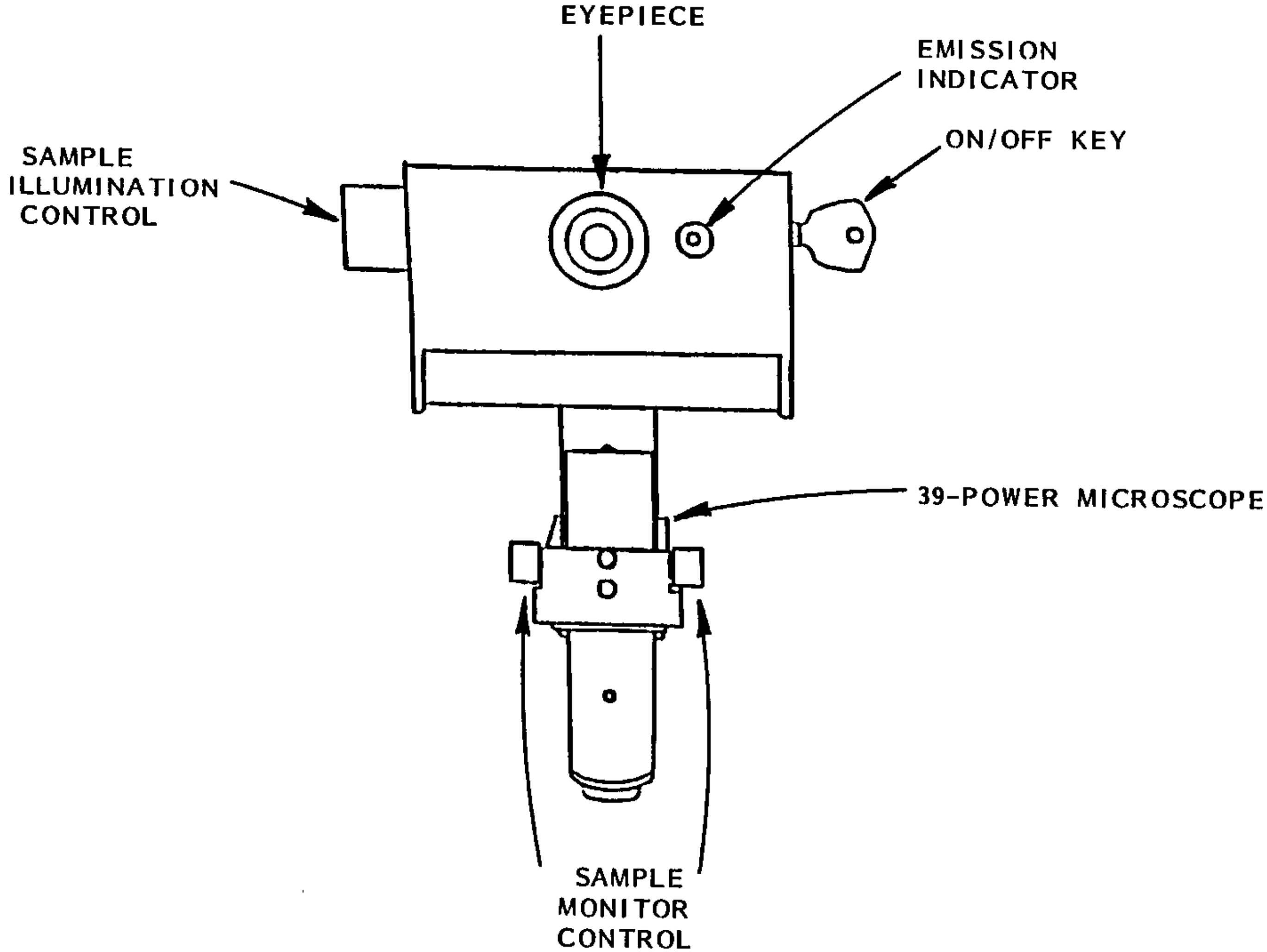


Figure 2-2 Ellipsometer controls and indicators on the Sample Monitor Assembly.

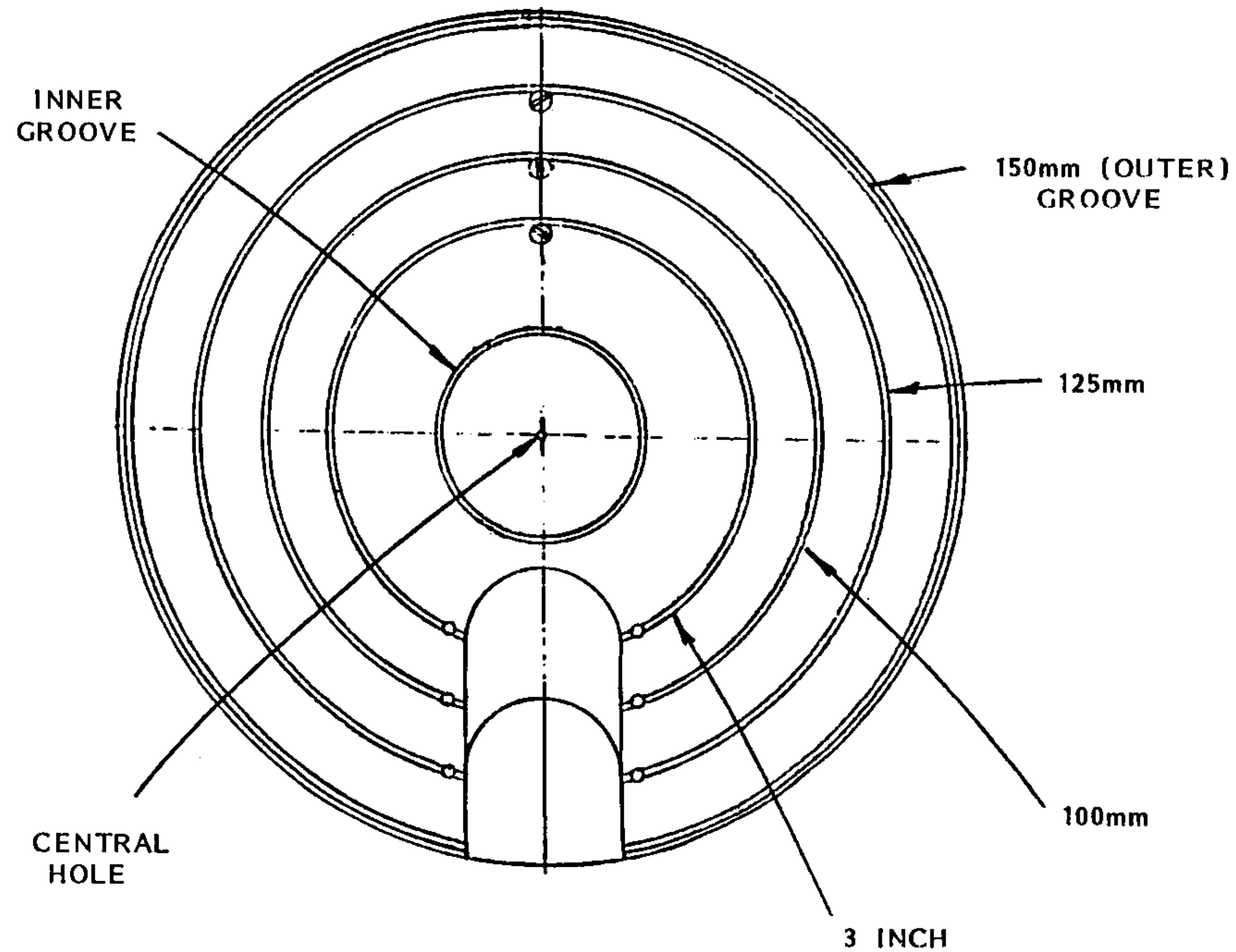


Figure 2-3 Top view of the 150 mm (approximately 6 inches) diameter sample table. See Figure 6-1 in the Optional Components Section for the top view of the optional 200 mm diameter table.

1.3 Sample Table Vacuum and Alignment (continued)

e. Observe the intersection of the two wide diagonal lines and the intersection of the narrow crosshairs. Slowly rotate as needed the X- and Y-plane tilt adjustment controls (Figure 2-4) to center the diagonals precisely on the crosshairs intersection. This makes corrections for the sample surface out-of-flatness condition.

NOTE

The width/height of the intersection of the diagonals is four arc minutes. This may be used as a reference in determining the approximate tilt adjustment needed.

f. Using the adjustment wheel under the rear of the table and the TMAX option of the program STDS (Section 3, Standard Programs), raise or lower the table for the maximum reading (Figure 2-5). A clockwise rotation of the wheel raises the table.

g. If the reading from the previous step overshoots the graph upper limit, or is too low, press the "s" key on the computer keyboard to change sensitivity. Then readjust the table slightly for a maximum reading. Repeat the adjustment of the drum and the table vertically, as needed, for a maximum reading.

h. Repeat steps e through g as often as necessary to fine tune the sample table adjustment.

i. Tighten the sample table clamp screw.

j. See the standard single-point program instructions (such as STDS) in the Standard Programs Section for the loading instructions, and use the Film program or subprogram. Proceed to make a measurement.

k. Compare the thickness data measurement with previously acquired sample thickness data. The compared data should be within ±3 Å (±0.3 nm).

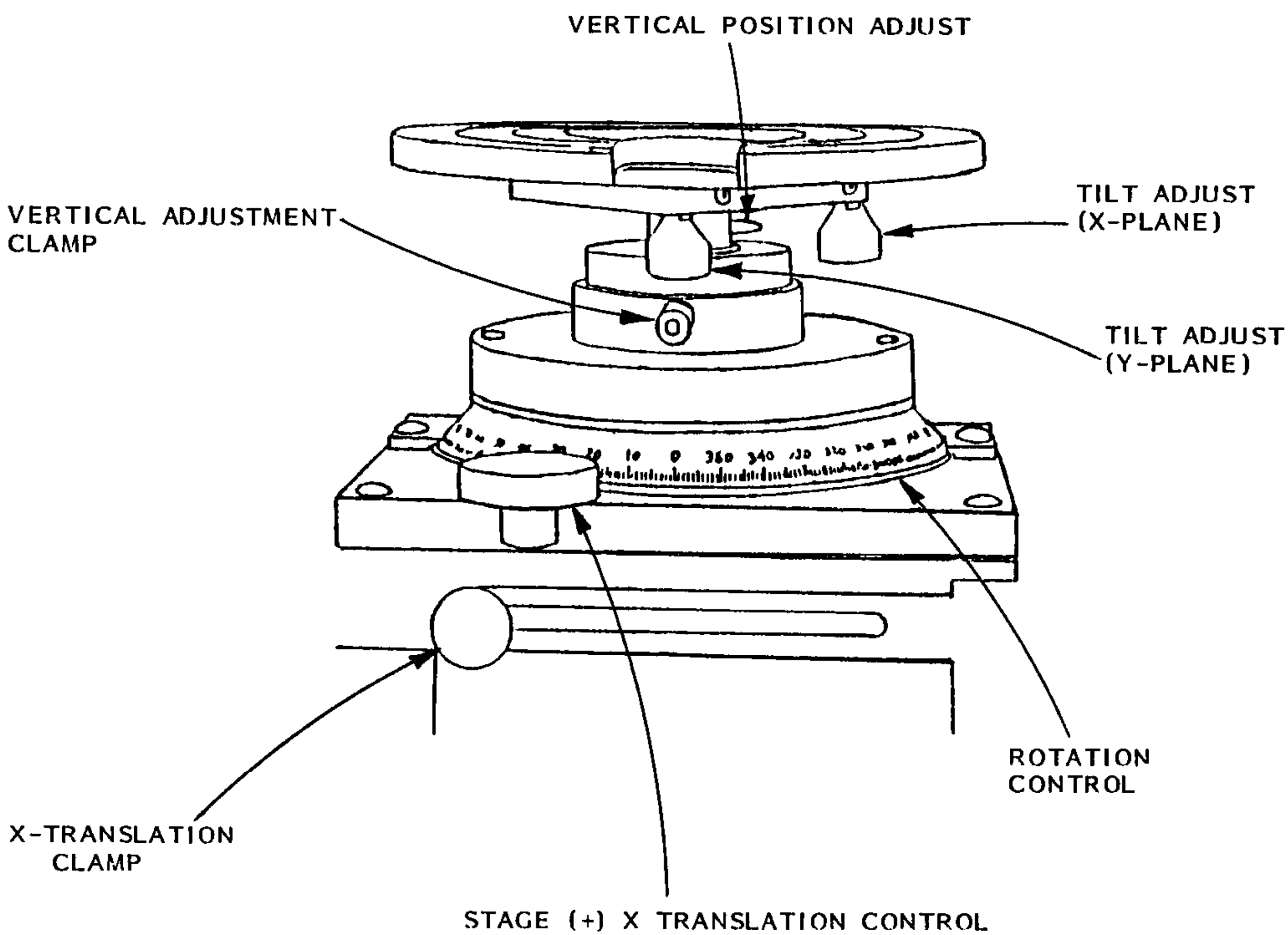


Figure 2-4 L116C Sample Stage and Table.

2.0 MEASUREMENT PROCEDURE

Place the sample wafer on the sample table, load the program software into the computer, and initiate the measurements. Once the measurements are started, press the keys as the screen and instructions request, then measurements are automatic.

Some measurements can be made after a 15-minute ellipsometer warmup, the stability of the laser improves after a few hours, which is better for important measurements. If the ellipsometer is in use several times a day, the laser should operate continuously.

WARNING

To avoid the hazard of laser beam dispersion, the beam attenuator must be closed while you adjust the polarizer or analyzer arm, or when the two arms are not at the same angle of incidence.

2.1 Standard and Optional Programs

Valid measurements are dependent upon the selection of a program applicable to the sample being measured, and correct interaction by the user with the computer. The standard programs supplied with the ellipsometer are in the Standard Programs section. The optional programs available by special order are identified in the Optional Programs section, first page.

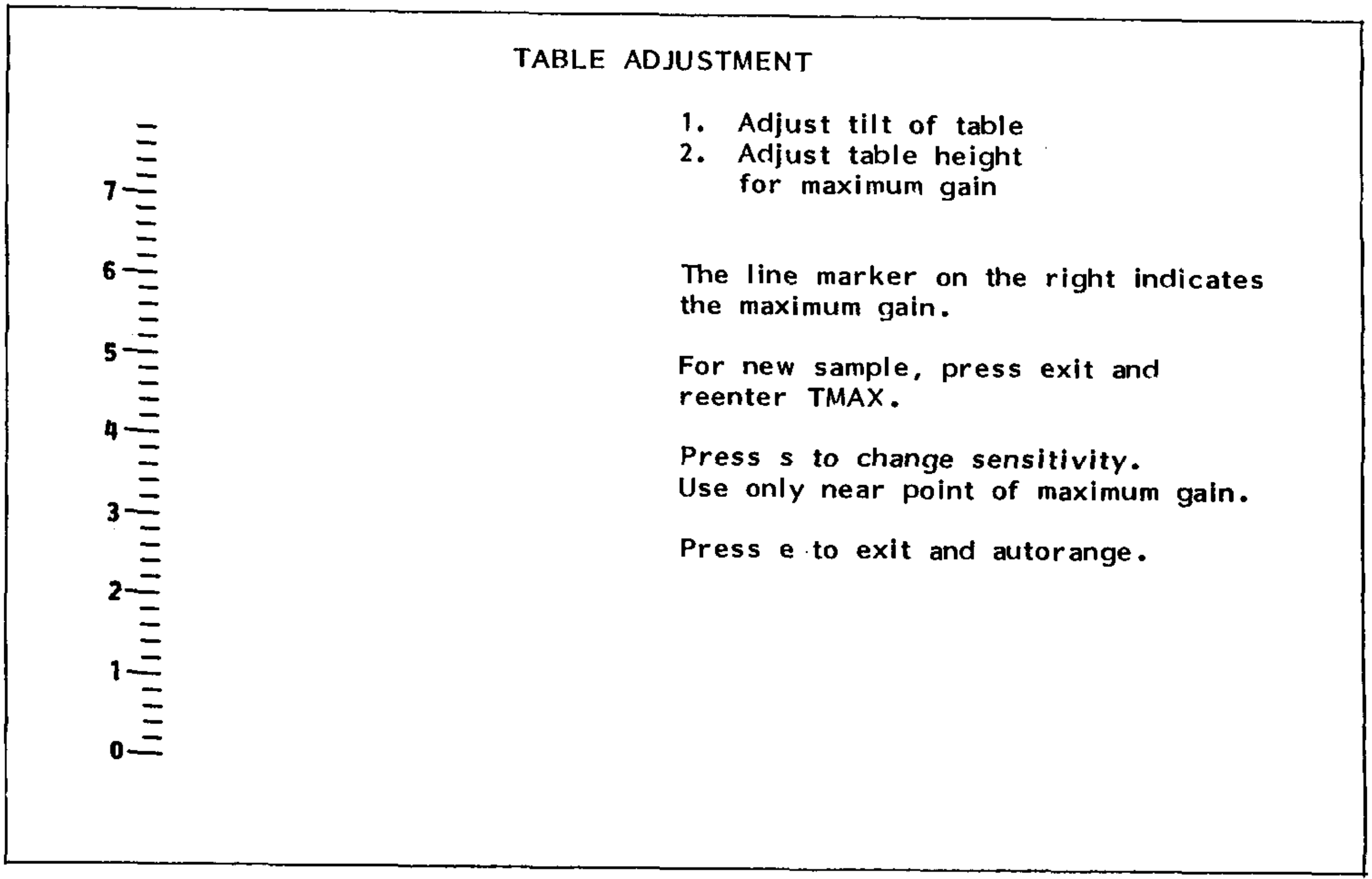


Figure 2-5 Computer screen displaying the photodetector output vertically.

3.0 USER MAINTENANCE

These maintenance instructions are operator-level procedures for routine servicing. See the Service Section regarding trouble analysis, adjustment, and replacement (qualified service personnel only) of defective components. Instructions are not included for the replacement of any laser or polarizer/analyzer optical or precision electro-mechanical components. Contact Gaertner Scientific Corporation for the repair or replacement of these items.

3.1 Cleaning

Interior cleaning of the ellipsometer (i.e., the four detector measurement head, monitor assembly and instrument power supply) should not be needed. These units are designed to keep foreign matter out. When not being used, the ellipsometer should be enclosed by the dust cover supplied with the instrument. Exposed optical surfaces may be cleaned with a camel-hair brush or clean, dry compressed air (not to exceed 5 PSI). All other external surfaces may be wiped clean using a soft, lint-free cloth. If a solvent is needed, a cloth dampened with wood or isopropyl alcohol is recommended.

NOTES:

TABLE OF CONTENTS

SUBSECTION PAGE

LIST OF FIGURES

CHARTS

1.0 INTRODUCTION AND SET UP

Gaertner Ellipsometer program software is supplied on two types of discs for use on the IBM PC and PS Series Computers. The program software for the IBM computers are as follows:

- IBM PC and IBM PC XT Computers are supplied on discs compatible with a 360k-byte, 5-1/4" drive.
- The IBM PS/1 Computer is supplied on discs compatable with a 1.4M-byte, 3-1/2" drive.
- The IBM PC AT Computer is supplied on discs compatible with a 1.2M-byte, 5-1/4" drive.

This system is set up according to Section 5, Installation.

1.1 Software Installation and Loading

See "Software Installation and Loading" in the Installation Section (5) of this *manual*.

1.2 The Sample Stage or Table Alignment

See "Sample Table Vacuum and Alignment" in the Operation Section (2) of this *manual*.

2.0 STANDARD PROGRAM (S6S + S7S + G5S + SubS) STDS

This is a single-layer, nonabsorbing (transparent) film program with three subprograms. The following line will be displayed in the lower left corner of the screen:

"SELECT KEY FROM BELOW AS DESIRED
1PRINT 2DISP"

Press F1 if the printer is connected and on and is to be used. Otherwise, press F2. Pressing either F1 (PRINT) or F2 (DISP) will produce the main menu:

"SELECT KEY FROM BELOW AS DESIRED
1FILM 2SUBSTR 3TWOANG 4END"

Press F1 (FILM) to select subprogram S6S + G5S, in which oxide or nitride films are evaluated See Figure 3-1.

Press F2 (SUBSTR) to select subprogram SubS, which evaluates bare substrates like silicon.

Press F3 (TWOANG) to select subprogram S7S, which takes measurements at both 50° and 70° and determines the proper film thickness order.

Press F4 (END) to exit a program so that any other program on the disc or on another disc can be entered. Be sure to turn off the computer to change discs.

Observe the display; and press function key F1, F2 or F3 corresponding to the desired subprogram; i.e., film (S6S + G5S), substrate (SubS), or two angle (S7S). This is the main menu. After working with one of the three subprograms, to return the main menu to the screen, press the MENU key (F10).

2.1 S6S + G5S Film Subprogram

When the Film subprogram is selected, these are the "Default Values" (left side of Figure 3-1, page 3-6):

- Silicon substrate: N_S=3.85; K_S=-.02
- Wavelength 6328Å (632.8 nm)
- SiO_2 (oxide) film: Estimated index, N=1.46*
- Mode of measurement: Measure N and thickness
- Angle of incidence: PHI=70°
- Polarizer drum angle: POL=20°

*For the silicon nitride films, the estimated index is N=2.00.

NOTE: To change any parameter below, press SETUP (F3).

Any one of the following can be selected by using the corresponding key in the Film program menu (bottom of Figure 3-1):

Key	Function
F1 (PRINT/DISP)	This allows the choice of printed or displayed output.
F2 (TMAX)	This activates the TableMax subprogram (Section 2).
F3 (SETUP)	This allows the setup of the input parameters.
F4 (SAMPLE)	The user enters identifying numbers and/or letters.
F5 (OXIDE)	This automatically fixes or measures index N.
F6 (NITRIDE)	This is the same as the above except for nitrides.
F7 (N MEAS)	This calculates index N and thickness.
F8 (N FXD)	This fixes index N and calculates only thickness.
F9 (LIST)	This gives a listing of all of the possible thicknesses (periodic multiples).
F10 (MENU)	This returns the main menu to the screen, where the substrate or two-angle subprogram can be selected.

2.1 S6S + G5S Film Subprogram (continued)

As seen on these pages, it is very often important to know the periods of the oxide and/or nitride films when making measurements. The table below gives the periods for oxide and nitride films at 50° and 70° with the red laser (at 6328 Å).

FILM	N_f	50°	70°
OXIDE	1.46	2545	2832
NITRIDE	2.00	1713	1792

For very thin films or films close to a periodic multiple, the sensitivity of the index measurement is very poor; therefore, accurate thickness measurements can be obtained only by fixing the value of the index (N) and then calculating the thickness. The two-angle subprogram (S7S) finds the absolute thickness of thick films, based on the order or period from matched measurements at each angle.

The SETUP key (F3) allows entry of substrate values, fixing or measuring of index (N), estimated value of index (N), angle of incidence (PHI), and expected film thickness. Default values for the above parameters will be displayed. Pressing Enter with no entry produces defaults to these values. Otherwise, other desired values (parameters) may be entered. Press Enter after entry.

The SAMPLE key (F4) allows the user to assign identification letters and/or numbers to a sample.

If the OXIDE key (F5) is selected (for oxide films), the program automatically determines whether the index (N) should be fixed or measured. The same is true for nitride films if the NITRIDE key (F6) is selected. Hence, for either oxide or nitride film on a silicon substrate at 70° angle of incidence, the above keys are recommended.

2.1 S6S + G5S Film Subprogram (continued)

NMEAS (F7) and NFXD (F8): The automatic fixing or measuring of the index (N) can be avoided by using function keys (N_{fxd}) and (N Meas). These keys fix the index (N) and measure the index (N) respectively, regardless of sensitivity considerations, although sometimes answers may not be computed. For example: if attempting to measure the index (N) of very thin films (under 100 Angstroms or 10 nm) it may not be possible to compute an answer. But, if the index (N) is fixed, the thickness will be computed. One oxide film example is this (appears in the center of Figure 3-1 while "Select optional from below" disappears):

```
SAMPLE:xxx
THICK:        Nf         PSI:       DEL:
 1051         1.464      44.48      79.33
```

The LIST key (F9) gives the thickness and the eight smallest possible thicknesses with a given period. One example is this (appears in the lower-right of Figure 3-1):

```
LISTING: (PERIOD= 2819Å)
  1051    9508  17965
  3870   12327  20784
  6689   15146  23603
```

One nitride film example of a display is this (center of Figure 3-1):

```
SAMPLE:nnn
THICK:        Nf         PSI:       DEL:
 264          1.986      15.81      106.07
```

The LIST key (F9) gives (lower right of the screen) the thickness and the eight smallest possible thicknesses with a given period. One example is this:

```
LISTING: (PERIOD= 2819Å)
   264    5691  11118
  2073    7500  12927
  3882    9309  14736
```

GAERTNER G5S + SubS + S6S + S7S AUTOMATIC ELLIPSOMETRY PROGRAM
FOR IBM PC

N_s = 3.850
K_s = -0.020
WL = 6328
N = 1.460
PHI = 70.00
POL = 45.00

Select Option From Below:

1PRINT 2TMAX 3SETUP 4SAMPLE 5OXIDE 6NITRIDE 7NMEAS 8NFXD 9LIST 10MENU

Figure 3-1 Screen display with the Standard Film subprogram Program Menu at the bottom.

2.2 SubS Substrate

Press F2 (SUBSTR) when the main menu is displayed (see subsection 2.0, "Standard Program") and subprogram SubS is selected so that the optical constants (PSI, DEL, real N_S and extinction k_S) of a bare substrate can be evaluated. These constants are needed before making any film measurements. Pressing MENU (F5) enters the main menu.

The angle of incidence (70°) is selected automatically. Verify that the polarizer drum is at 20°.

- Angle of incidence: PHI=70°
- Polarizer drum angle: POL=20°

Any one of the following can be selected by using the corresponding key:

Key	Function
F1 (PRINT/DISP)	Allows the choice of printed or displayed output.
F2 (TMAX)	Activates the TableMax subprogram.
F3 (PHI)	Allows change of angle of incidence to other than 70°.
F4 (MEAS)	Instructs the ellipsometer and computer to make a measurement with the given input parameters.
F5 (MENU)	Terminates the Substrate subprogram and returns the program to the main menu.
F6 (SAMPLE)	Allows identifying numbers and/or letters to be entered.
F7 (POLRZR)	Allows the input of the polarizer drum setting (normally 20°) for the best overall sensitivity. By setting the polarizer drum close to the value of PSI, sensitivity and stability can be increased.

At ϕ = 70°, one substrate produced these measurements (middle of the screen):

SAMPLE:Sss

Ns:	Ks:	PSI:	DEL
3.791	-0.153	9.99	173.21

2.3 S7S Two Angle

The ellipsometric thickness measurement of transparent films is a periodic function. When using only one angle of incidence, the expected thickness of the film has to be known within a period. For SiO_2, a period is 2832Å (283.2 nm) at a 70° angle of incidence. If the thickness is not known to this accuracy, then measurements at two angles of incidence are needed to find the actual film thickness.

Press F3 (TWOANG) in the main menu to select subprogram S7S, which takes measurements at both 50° and 70° for the most accurate film thickness measurements. A sample serial number and/or letters can be typed in and press Enter. Just press Enter for no number. Then select Oxide (F1), Nitride (F2), or Nf (F3).

The Two Angle program requires the cooperation of the user (in changing the angle of incidence), in taking measurements at 70° and 50° angles of incidence on Oxide or Nitride films on Silicon substrates, and determines the actual thickness of films. The thickness does not have to be known within a period; however, minimum and maximum possible thicknesses, such as 0 and 30000, have to be entered. Following is an example of a nitride film display, as it appears in the center of the screen:

```
                  SAMPLE:nnn

                  PHI=70          PHI=50
              Nf FXD: 2.000    Nf FXD: 2.000
      MATCHED THICKNESS:   265        268

1PRINT  2TMAX  3OXIDE  4NITRIDE  5Nf?  6SAMPLE  7LIST  8PSIDEL  9MENU  10
```

2.3 S7S Two Angle (continued)

The LISTING key (F7) gives all of the possible thicknesses [within the minimum (0) and maximum (20000) entered] for 70° and 50° from which the actual thickness is matched. Different maximum values can be selected; a listing will appear on the right side of the screen. Following is a listing obtained using the above minimum and maximum:

THICKNESS LISTING:

PHI=70	PHI=50
265	268
2057	1981
3849	3694
5641	5407
7433	7120
9225	8833
11017	10546
12809	12259
14601	13972
16393	15685
18185	17398
19977	19111

For films, of thicknesses less than 400Å or within 400Å of a periodic multiple, the index will be fixed at 1.46 for oxides and 2.00 for nitrides. Any other default index may be entered as prompted.

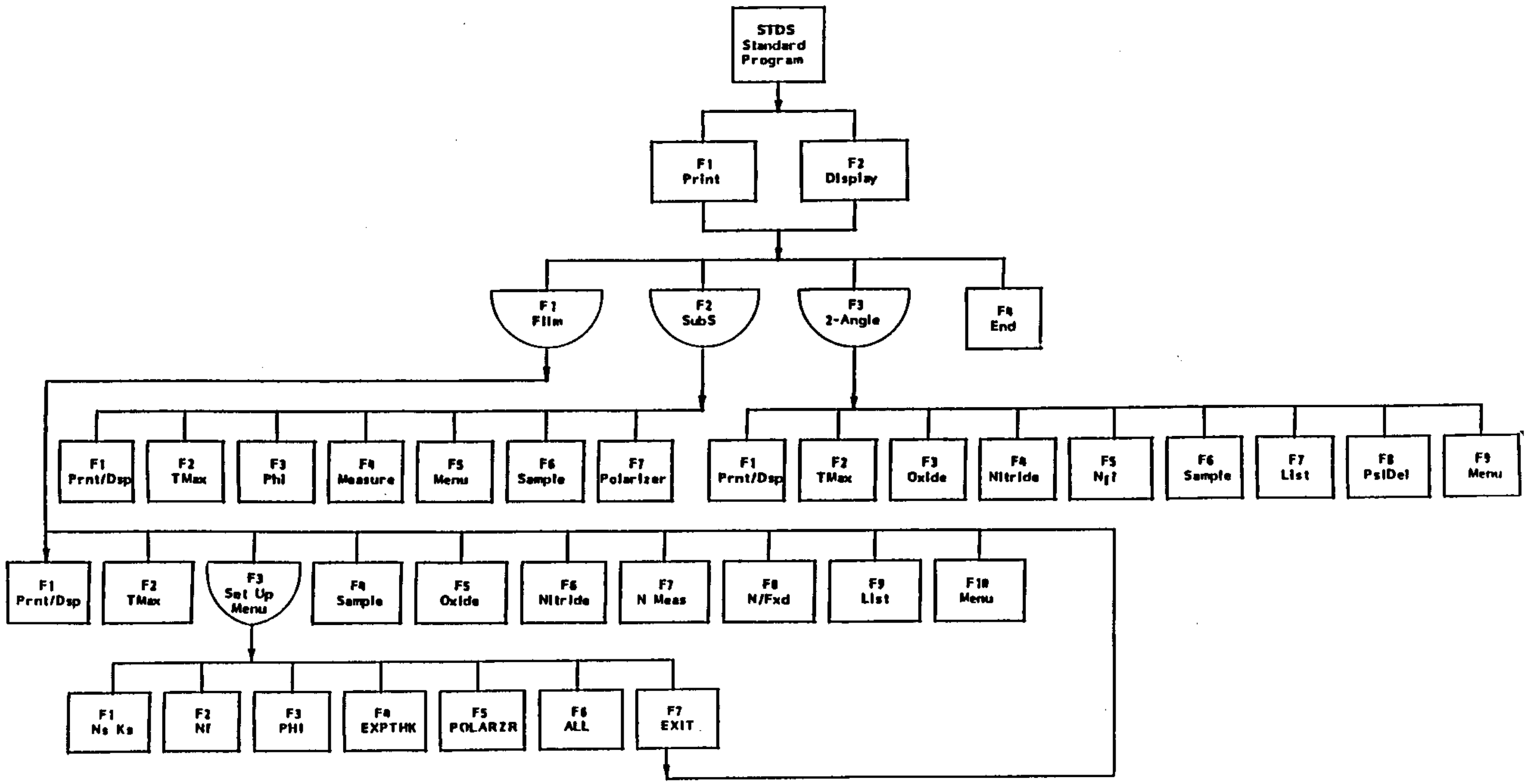


Chart 3-1 Standard Program Flow Chart

NOTES:

SINGLE-POINT MEASUREMENTS

TABLE OF CONTENTS

INFORMATION ON THE ABOVE OPTIONAL PROGRAMS
IS AVAILABLE THROUGH GAERTNER SCIENTIFIC CORPORATION

TABLE OF CONTENTS

SECTION PAGE

LIST OF FIGURES

LIST OF CHARTS

1.0 INTRODUCTION

The WS11A Optional Program is a specific two-layer, waferskan measurement, absorbing film program for use with the Gaertner L115C/D Waferskan Ellipsometer and an IBM PC/PS Computer. The program calculates thickness and absorption of a polysilicon film on a layer of oxide or nitride with a silicon substrate. It is a modified version of the WS Standard Waferskan Program.

This instruction describes the unique features and functions of the WS11A Optional Program. To work effectively in the program a thorough familiarity with the WS Standard Waferskan Program is recommended. While the WS11A optional instruction may describe, in some cases, a procedure where the two operations are similar, in some other instances, where the two programs are identical, no reference is made because the point has been discussed in detail in the standard waferskan program instruction.

2.0 SET UP

Refer to the INSTALLATION Section and the "Program Software" Instructions (#7109-C-123) in the STANDARD PROGRAMS Section for information regarding setup, software installation and loading, and table vacuum and alignment.

3.0 STARTING THE PROGRAM

Several seconds after the WS11A program is selected from the waferskan system software menu, Figure 4-6.1, the Main Menu appears.

Select Option:		
1:Production	2:Engineering	10:END

Figure 4-6.1 Option portion of the WS11A Main Menu screen.

4.0 WORKING IN THE ENGINEERING MODE

To start the Engineering Mode press the F2:Engineering key in the Main Menu. A screen similar to Figure 4-6.2 appears.

```
WS11A:            SETUP file: Default            Solve:  Kf index

Film parameters for the Polysilicon on Oxide or Nitride:
Poly       -Thick (exp): ?      Nf (fxd):  4.060    Kf (exp):  -0.049
Oxide      -Thick2(fxd): 0      Nf2(fxd):  1.460    Kf2(fxd):  -0.000
Substrate  -Ns:  3.850          Ks:  -0.020

INSTRUMENT PARAMETERS          5-Point WAFERSKAN PARAMETERS
 Wavelength (A) :  6328         Plot:  Thickness
 Phi            : 70.00         Wafer diameter-mm:  150.00
 Ambient        : 1.000         Outer meas dia-mm:  132.00
 Polarizer Angle : 45.00        Measure center point: Yes

                                STATUS
```

Figure 4-6.2 Typical parameter box section of the Engineering Mode screen.

Enter these parameter values in the following order:

1. Poly thickness . . . . . expected thickness entry is required in the initial film setup.
2. Poly N_f(fxd) . . . . default value=4.060 at 6328Å.
3. Poly K_f(exp) . . . . default value=-0.049 at 6328Å.
4. Oxide: Thick2(fxd) . . entry is required in the initial film setup.

4.0 WORKING IN THE ENGINEERING MODE (continued)

When all the parameter values are entered, the screen display is similar to Figure 4-6.3.

```
WS11A:          SETUP file: Default          Solve:  Kf index

  Film parameters for the Polysilicon on Oxide or Nitride:
  Poly       -Thick (exp):  500   Nf (fxd):  4.060    Kf (exp):  -0.049
  Oxide      -Thick2(fxd):  100   Nf2(fxd):  1.460    Kf2(fxd):  -0.000
  Substrate  -Ns:  3.850          Ks:  -0.020

INSTRUMENT PARAMETERS          5-Point WAFERSKAN PARAMETERS
 Wavelength (A) :  6328        Plot:  Thickness
 Phi            : 70.00        Wafer diameter-mm:  150.00
 Ambient        : 1.000        Outer meas dia-mm:  132.00
 Polarizer Angle : 45.00       Measure center point: Yes

                               STATUS
Select Option:

1:Pmtrs   2:Exe   3:SetupFiles   4:Sample   5:PrtON   8     10:Exit
```

Figure 4-6.3 Typical Engineering Mode screen of the WS11A program. Arbitrary values for an Oxide layer have been entered.

4.0 WORKING IN THE ENGINEERING MODE (continued)

Choose any option of the Engineering Mode in any order as needed:

Key	Function
F1:Pmtrs	Set or change the values of the parameters (section 4.1).
F2:Exe	Execute a measurement with the current status of the parameters being displayed ("active set of parameters"). A menu choice is available between single-point and wafer scan measurement (section 1.2 of the WS instructions).
F3:SetupFiles	Save an active set of parameters or delete an existing set (section 4.2).
F4:Sample	Assign a sample ID to a graphic screen.
F5:PrtON/OFF	This is a toggle function.

Press:	Menu Display:	Printer Response:
F5:PrtON	F5:PrtOFF	**a.** Automatically print the measured value after each measurement (during the Execution). OR **b.** When the current parameters are displayed, press F5:PrtON, choose the corresponding options from the F1:Pmtrs menu and press F10:Exit to print the parameters.
F5:PrtOFF	F5:PrtON	The printer is deactivated.

Key	Function
F10:Exit	Terminate the Engineering Mode and return the WS11A Main Menu to the screen.

4.1 Setting Parameters

Use the F1:Pmtrs key to review and set/change the sample parameter values. The Engineering Mode menu is replaced by the Parameters menu when the F1:Pmtrs key is pressed (Figure 4-6.4).

4.1 Setting Parameters (continued)

```
WS11A:          *SETUP file: TEST3              Solve:  Kf index

  Film parameters for the Polysilicon on Oxide or Nitride:
  Poly        -Thick (exp): 500   Nf (fxd): 4.060    Kf (exp): -0.049
  Oxide       -Thick2(fxd): 100   Nf2(fxd): 1.460    Kf2(fxd): -0.000
  Substrate   -Ns:  3.850         Ks:  -0.020

INSTRUMENT PARAMETERS            5-Point WAFERSKAN PARAMETERS
  Wavelength (A) :  6328         Plot:  Thickness
  Phi            : 70.00         Wafer diameter-mm:  150.00
  Ambient        : 1.000         Outer meas dia-mm:  132.00
  Polarizer Angle : 45.00        Measure center point: Yes

                                 STATUS
Select Parameter Option:

1:Film                        4:Waferskan   10:Exit
```

Figure 4-6.4 Example of the Parameters option screen.

Key	Function
F1:Film	Set the Film parameters. See section 4.1.1.
F4:Waferskan	Set the parameters for a 5-Point, 9-Point, X-Y GRID, USER-Mode or 49-point Waferskan. See section 1.1.3 of the WS instructions.
F10:Exit	Terminate the Parameters option and return the Engineering menu to the screen.

4.1.1 Film Parameters

Choose the F1:Film option from the Parameters Menu (Figure 4-6.4) and the Film Parameters Menu appears at the bottom of the screen. Reference Figures 4-6.5 and 4-6.6.

```
WS11A:          *SETUP file: TEST3          Solve:  Kf index

Film parameters for the Polysilicon on Oxide or Nitride:
Poly        -Thick (exp):  500   Nf (fxd):  4.060    Kf (exp):  -0.049
Oxide       -Thick2(fxd):  100   Nf2(fxd):  1.460    Kf2(fxd):  -0.000
Substrate   -Ns:  3.850          Ks:  -0.020

INSTRUMENT PARAMETERS          5-Point WAFERSKAN PARAMETERS
 Wavelength (A) :  6328        Plot:  Thickness
 Phi            : 70.00        Wafer diameter-mm:  150.00
 Ambient        : 1.000        Outer meas dia-mm:  132.00
 Polarizer Angle : 45.00       Measure center point: Yes

                               STATUS
Select film parameters:

2:Poly Layer    3:Oxide Thk    4:→Nitride          10:Exit
```

Figure 4-6.5 Example of the Film Parameters option screen. The second layer is an Oxide.

Key	Function
F2:Poly Layer	Enter new value(s) for thickness, refractive index and/or absorption of the Poly Layer (Top Layer).
F3:OxideThk/NitrideThk	Enter new thickness for the second layer. The F3 key label is changed automatically when the F4 key is toggled.
F4:→Nitride/→Oxide	Toggle function: Change the second layer from Oxide to Nitride (press →Nitride) or from Nitride to Oxide (press →Oxide).
F10:Exit	Terminate the Film Parameters option and return the Parameters menu to the screen.

4.1.1 Film Parameters (continued)

```
WS11A:          *SETUP file: TEST3                Solve:  Kf index

  Film parameters for the Polysilicon on Oxide or Nitride:
  Poly       -Thick (exp):  500   Nf (fxd):  4.060    Kf (exp):  -0.049
  Nitride    -Thick2(fxd):  100   Nf2(fxd):  2.000    Kf2(fxd):  -0.000
  Substrate  -Ns:  3.850          Ks:  -0.020

INSTRUMENT PARAMETERS          5-Point WAFERSKAN PARAMETERS
 Wavelength (A) :  6328        Plot:  Thickness
 Phi            : 70.00        Wafer diameter-mm:  150.00
 Ambient        : 1.000        Outer meas dia-mm:  132.00
 Polarizer Angle : 45.00       Measure center point: Yes

                               STATUS
Select film parameters:

2:Poly Layer   3:Nitride Thk   4:→Oxide        10:Exit
```

Figure 4-6.6 Example of the Film Parameters option screen. The second layer is a Nitride.

4.2 Setup Files

The active set of parameters can be stored into a SETUP File and used later in the Production Mode. Press the F3:SetupFiles key in the Engineering Menu (Figure 4-6.3) to display the SETUP files list.

```
Disc Drive C:\00TTT                                                 5 files
Files currently on disc
File name              Date            Store Option        Film Mode
 RED1       :       05-22-1995         SETUP DATA          WS
 RED2       :       05-22-1995         SETUP DATA          WS
 TEST1      :       12-06-1995         SETUP DATA          WS11A
 TEST2      :       12-06-1995         SETUP DATA          WS11A
 TEST3      :       12-06-1995         SETUP DATA          WS11A
                 <<<<    End of File List    >>>>

Select option:
-----------------------------------------------------------------------
1:Store    3:Delete            7:Up     8:Down     10:Exit
```

Figure 4-6.7 Example of an Engineering Mode SETUP files list screen (DIRECTRY.00TTT).

Key	Function
F1:Store	Store the active set of parameters to an external SETUP file to use later. Only WS11A film mode files can be created and then used in the Production Mode with this WS11A optional program.
F3:Delete	Delete any existing SETUP file in the list (WS, WS11A or any other optional program film mode, i.e., WS6A, WS8A, etc.).
F7:Up	Roll the screen up. The number of files in the list appears in the upper right corner. Screen capacity is 14 files. If more files are available, the legend "···· more ····" appears at bottom of the page.
F8:Down	Roll the screen down.
F10:Exit	Terminate the SETUP Files program and return the Engineering Mode menu to the screen.

5.0 WORKING IN THE PRODUCTION MODE

Press the F1:Production key in the WS11A Main Menu (Figure 4-6.1) to begin working in the Production Mode. The Production Mode pathway is the same as the WS Standard Waferskan Program pathway.

```
Disc Drive C:\00TTT                                          5 files
Files currently on disc
File name              Date          Store Option      Film Mode
 RED1       :       05-22-1995       SETUP DATA        WS
 RED2       :       05-22-1995       SETUP DATA        WS
 TEST1      :       12-06-1995       SETUP DATA        WS11A
 TEST2      :       12-06-1995       SETUP DATA        WS11A
 TEST3      :       12-06-1995       SETUP DATA        WS11A
                  <<<<   End of File List    >>>>


Select one option:
--------------------------------------------------------------------
1:Retrieve file            7:Up     8:Down     10:Exit
```

Figure 4-6.8 Example of a SETUP file list in the Production Mode. It is the first screen of the WS11A Production Mode.

Key	Function
F1:Retrieve file	Retrieve a WS11A SETUP file for execution of a measurement. Only a file created in this WS11A optional program can be retrieved.
F7:Up	Roll the screen up. Screen capacity is 14 files. The total number of files in the list is shown in the upper right corner.
F8:Down	Roll the screen down.
F10:Exit	Terminate the Production Mode and return the WS11A Main Menu to the screen.

5.0 WORKING IN THE PRODUCTION MODE (continued)

```
Disc Drive C:\00TTT                                          5 files
Files currently on disc
File name              Date          Store Option      Film Mode
 RED1        :       05-22-1995      SETUP DATA        WS
 RED2        :       05-22-1995      SETUP DATA        WS
 TEST1       :       12-06-1995      SETUP DATA        WS11A
 TEST2       :       12-06-1995      SETUP DATA        WS11A
 TEST3       :       12-06-1995      SETUP DATA        WS11A
                   <<<<   End of File List    >>>>


Filename to retrieve (for a WS11A only)? RED1
Not a WS11A file !  <ENTER> key & retry.
     To Exit, press just <ENTER> key.
```

Figure 4-6.9 Example of an attempt to retrieve an out-of-mode file. RED1 is a WS Film Mode file and cannot be retrieved while working in the WS11A optional program. Only files TEST1, TEST2 and TEST3 can be retrieved at this time.

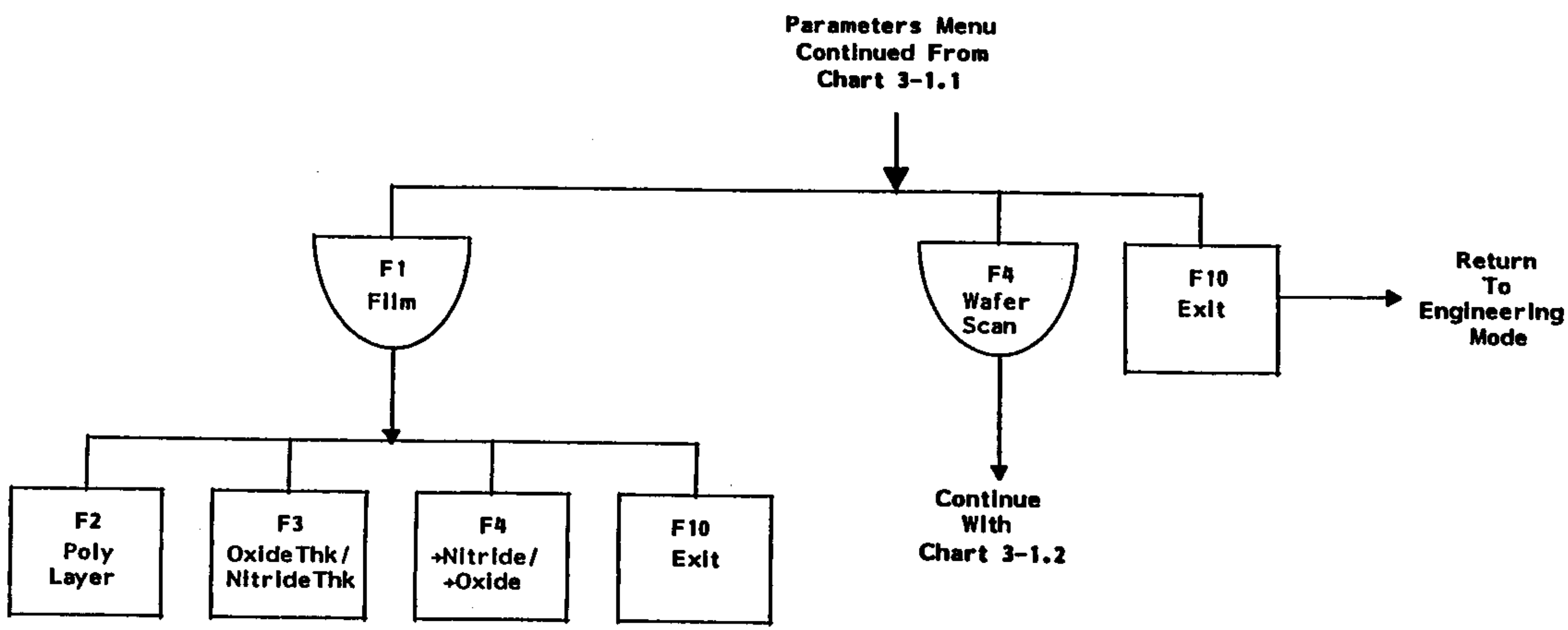


Chart 4-6.1 WS11A modification of the WS flow chart.

TABLE OF CONTENTS

LIST OF FIGURES

The Gaertner ellipsometer is shipped fully assembled, along with needed items, in a single shipping crate. The applicable items are as follows:

- Ellipsometer User's Manual
- Ellipsometer/Computer Interface Cable
- *Analog to Digital Converter Card
- Software Programs
- Silicon Wafer (Reference Sample)
- Dust Cover

*This component is supplied to customers with their own computers. But computers that are shipped with the ellipsometer will have the A/D card already installed.

UNPACKING

Remove the protective wrapping from the ellipsometer. Remove the lag bolts that secure the hold-down clamps to base of the ellipsometer. Remove the hold-down clamps. This allows the removal of the ellipsometer from the shipping crate base platform. <u>DO NOT</u> apply any pressure on the laser.

NOTE

Store the shipping platform, shipping crate parts and protecttive wrapping in case of a reshipment to Gaertner for repair.

WHEN PACKING THE ELLIPSOMETER FOR RESHIPMENT TO GAERTNER FOR REPAIR, INCLUDE THE SOFTWARE PROGRAMS AND INTERFACE CABLES (WITH A/D INTERFACE CARD, IF APPLICABLE). CONTACT GAERTNER FIRST.

CAUTION

In event of reshipment, care must be taken to ensure that (1) the polarizer arm is set and clamped at 50° angle of incidence and (2) the analyzer arm is set and clamped at 50° angle of incidence before packing. This will prevent damage to the helium-neon (red) laser assembly and analyzer module.

INSPECTION

Thoroughly inspect the ellipsometer for shipping damage. If there is damage from transit, notify the carrier.

A key should be installed in the keylock switch located on the right side of the Sample Monitor Assembly (above the sample table); it should be off. Check that good a fuse is in the ellipsometer. Verify that all applicable items have been included in the shipment.

LOCATION CONSIDERATIONS

The Gaertner ellipsometer is designed for use in either a production or laboratory facility under relatively constant room temperature and a relatively dry, dust-free atmosphere. The ellipsometer requires a clean, level solid work surface sufficient to also accommodate the interfaced computer. The input ac line voltage must be free of large transients having harmonics in the range from audio frequencies to several megahertz. Do not obstruct the ventilation holes on any of the equipment.

INTERCONNECTIONS

DO NOT plug or unplug any component into or from ac power or make connections to other equipment with its power ON/OFF switch ON!

The ac line cable for the ellipsometer is on the left side, near the rear of the instrument power supply and is labeled INPUT POWER. The ac line cable for the helium-cadmium laser assembly is at the rear of the laser power supply.

CAUTION

Verify that the power switches on all of the components are OFF before connecting or disconnecting the interface cabling.

An interconnection diagram for the ellipsometer is shown in Figure 5-2.

Ellipsometer and Computer See Figure 5-3 (ellipsometer rear view), and Figure 5-4 (IBM PS/1 computer). See Figure 5-5 (A/D interface card), and Figure 5-6 (A/D interface card with cable adapter removed).

AC POWER PLUGS

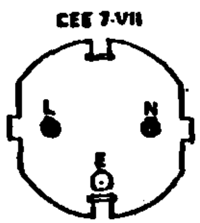
The Gaertner ellipsometer is supplied with a U.S. plug (NEMA 5-15P). If it is necessary to change the plug, the following guidelines apply:



Great Britain, Cyprus, Nigeria, Rhodesia and Singapore



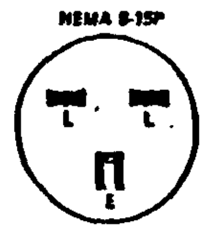
Australia and New Zealand



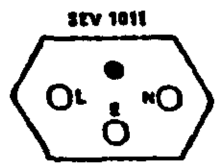
Eastern and Western Europe, Saudi Arabia, and United Arab Repuhlic



Underwriter's Laboratory approved for the United States, Canada, Japan, Mexico, Philippines and Tiawan



UL approved for the U.S.



Switzerland

Figure 5-1

NOTE: All plugs are for single-phase power and are viewed (above) from the connector end. The prongs are:

- L = Line or active conductor, also called "live" or "hot". The insulation is black.
- N = Neutral or identified conductor. The insulation is white.
- E = Earth or safety ground. The insulation is green.

Computer and Printer

Connect the Centronics Interface Cable (7108-E-239t) to the parallel receptable on the rear of the computer and at the connector on the printer. See Figure 5-3 (ellipsometer rear view), and Figure 5-4 (IBM PS/1 computer). Hand tighten the connector thumb screws.

SOFTWARE INSTALLATION AND LOADING

NOTE: Wherever in this instruction the prompt is to type in some specific characters, the characters are in **boldface** and just after "type". Type in the characters, and press Enter.

Software Installation on the Customer-Supplied Computer:

The computer will load DOS from the hard disc (which must have at least three megabytes of free space), drive C.

a. • Turn on the computer, allow it to "boot-up", and insert the program disk into drive A.

- The screen should show that drive C is the default by displaying, for example, the following: "C:\>". Type **a:** and press Enter to make A the default, i.e., "A:\>".
- Type **install** and press Enter. All of the files on the program disk will then be put on hard disc C.
- Remove the program disc. Go to step c. for installing any optional programs.

b. **NOTE:** The following occur during the software installation:

1) A directory is created: c:\gsc.
2) All of the driver and executable files are copied in that directory.
3) Autoexec.bat and config.sys files on c:\ root directory are created. If the autoexec.bat and config.sys files already exist on c:\ drive, it copies them to autoexec.bak and config.bak before installing new ones.

c. **OPTIONAL PROGRAM INSTALLATION:** If one or more optional programs has been ordered, place each optional program disc into drive A. The default drive should be A. If it is not, type **a:** and press Enter so that A is the default. Type **install** and press Enter. Remove the program disc.

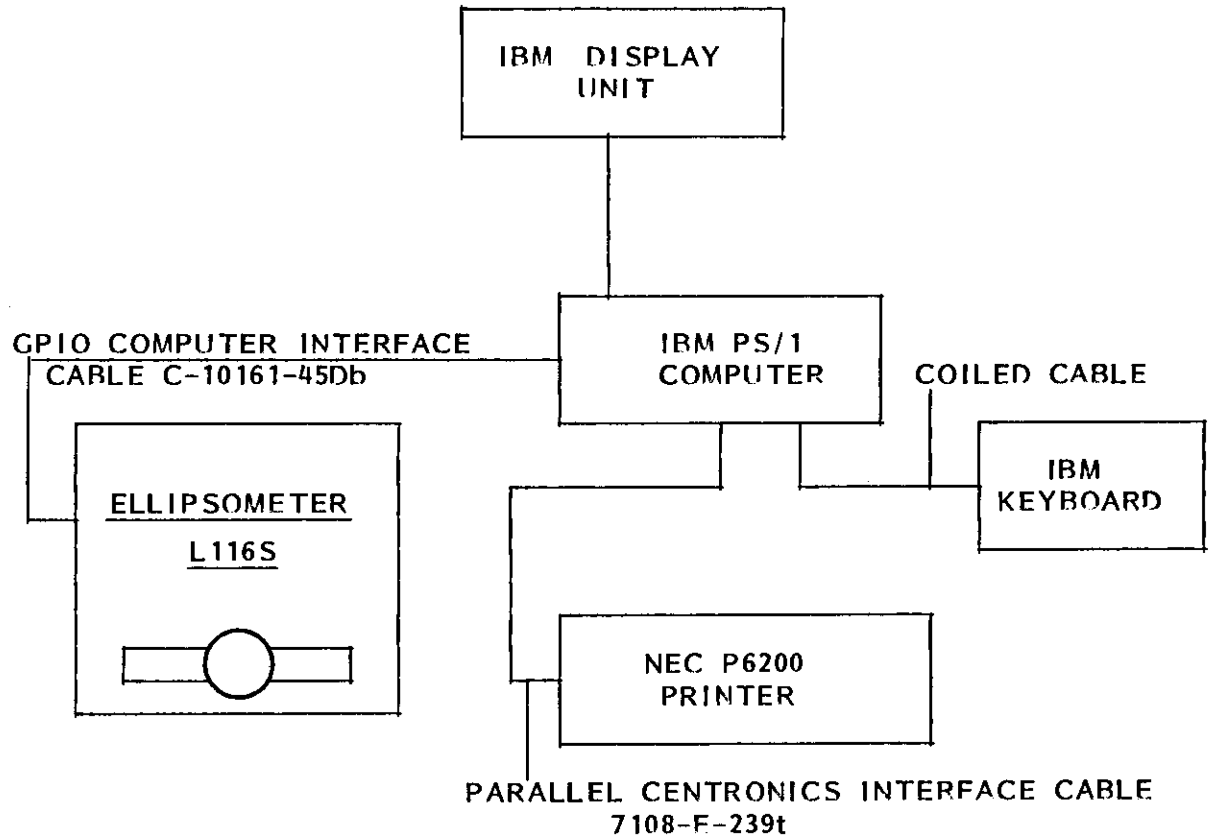


Figure 5-2 L116S Ellipsometer Interconnection Diagram. The computer that Gaertner will supply with the L116S is the IBM PS/1.

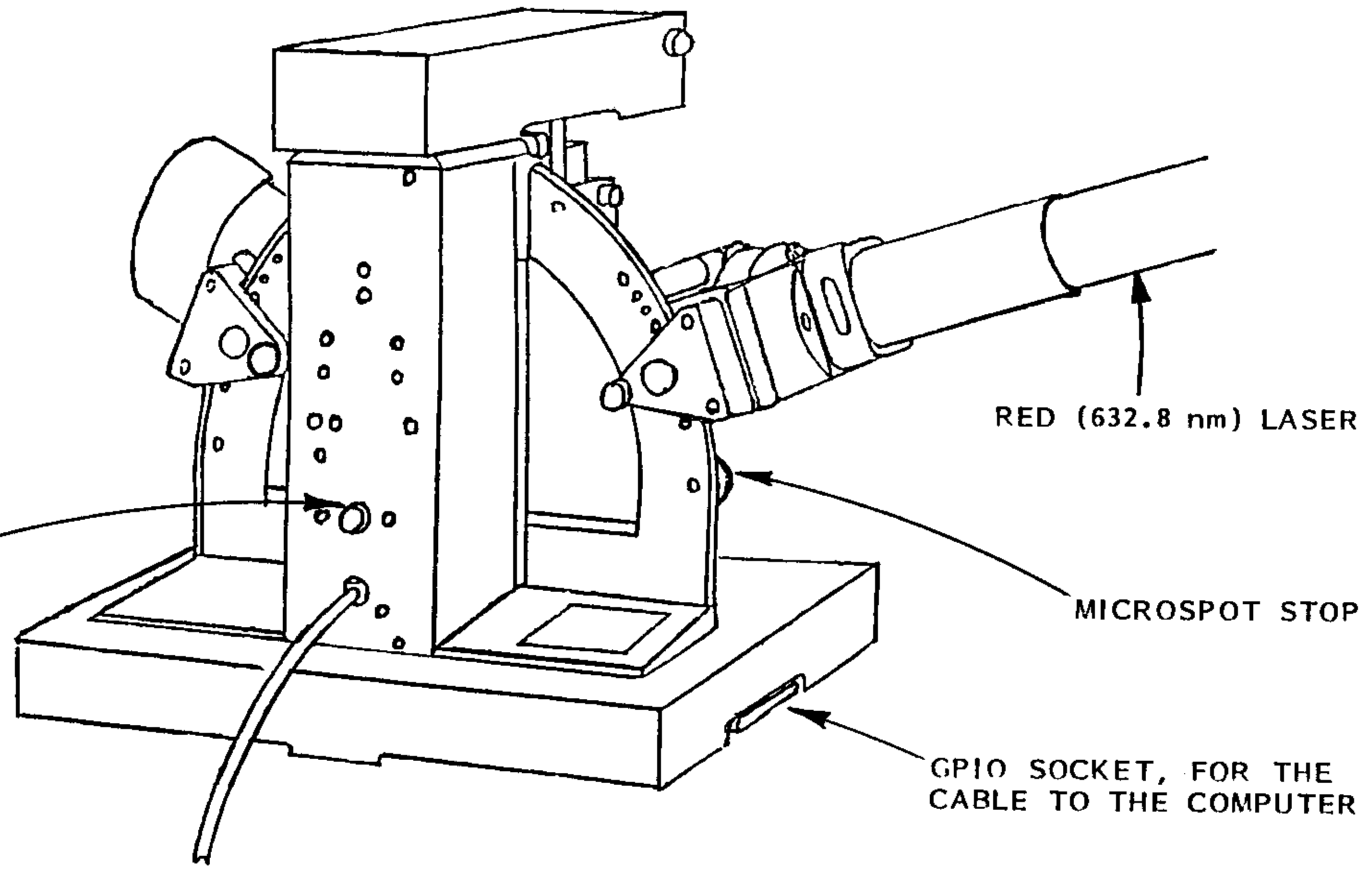


Figure 5-3 Rear and left view of the L116S Ellipsometer with the 6-inch diameter table and the 632.8 nm helium-neon laser.

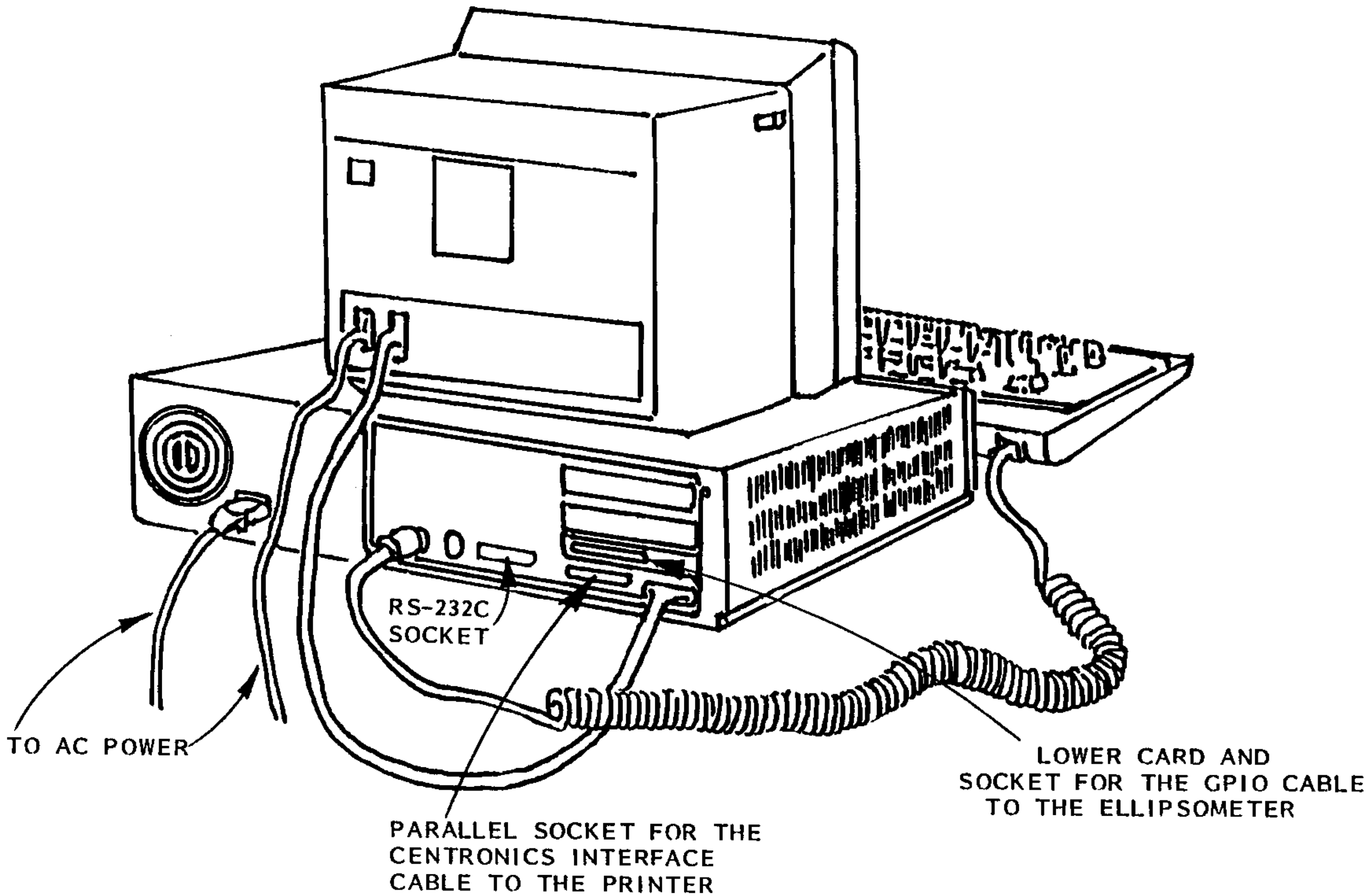


Figure 5-4 IBM PS/1 computer and its connections.

COMPUTER CIRCUIT BOARD INSTALLATION

INTRODUCTION

NOTE: If the computer was supplied by Gaertner along with the L116S, then the circuit boards mentioned here were already installed. Ignore this and the next two pages.

These instructions are for installing the A/D and GPIB Interface Cards and Cable assemblies into the IBM PS/1 computer for use with the L116S Ellipsometer for tests.

A/D INTERFACE CARD

The A/D Interface card with cable adapter is shown in Figure 5-5. This unit must be partially disassembled prior to installation in the computer. Begin by removing the stand-offs indicated in the Rear View of Figure 5-6.

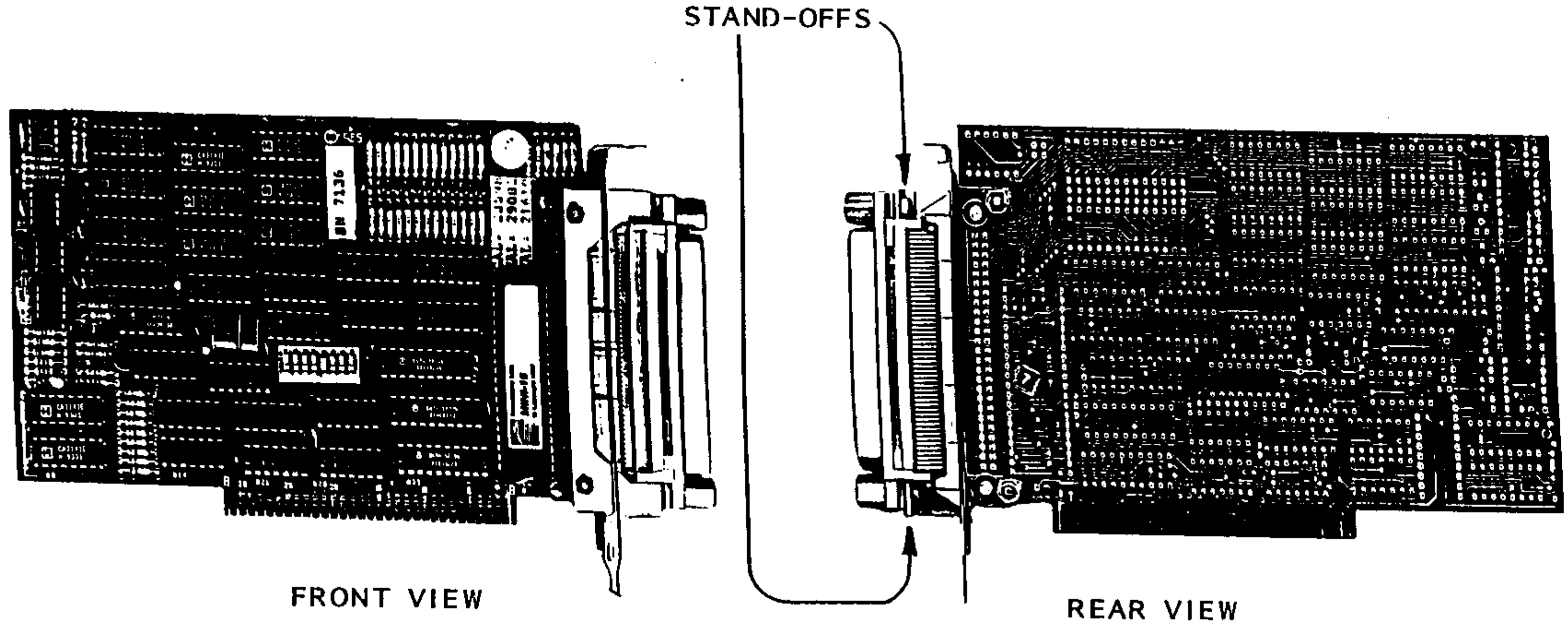


Figure 5-5 Photograph of the A/D Interface Card.

A/D INTERFACE CARD (Continued)

Now carefully remove the cable adapter as shown in Figure 5-6. The A/D card may now be securely seated into a computer expansion slot. Once the A/D card is properly installed, replace the cable adapter and stand-offs; then firmly tighten.

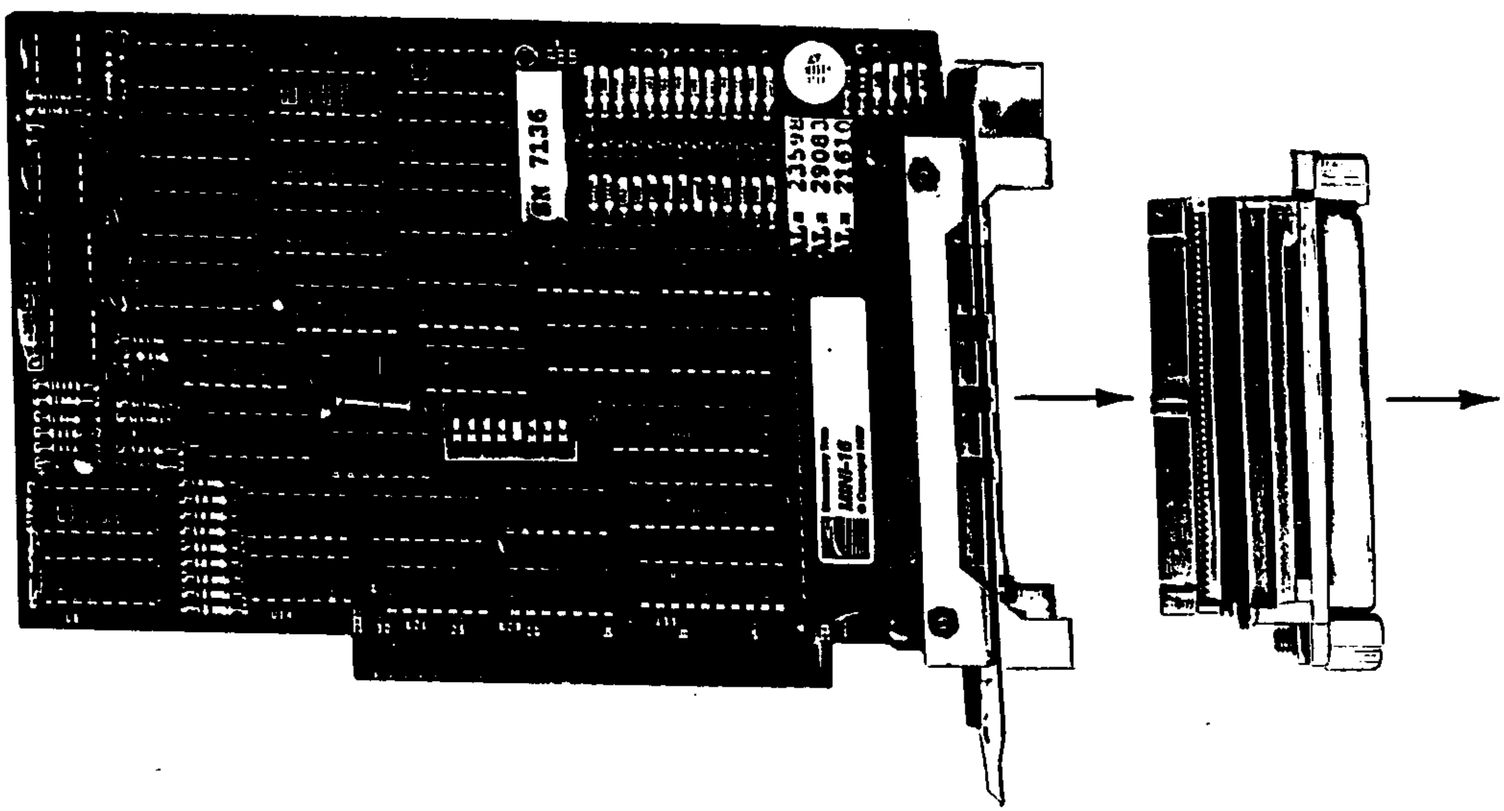


Figure 5-6 Photograph of the A/D Interface Card with the Cable Adapter removed.

TABLE OF CONTENTS

FIGURE

HAND POSITIONING STAGES

L116HXY6 - This stage accepts 6-inch samples and enables the sample table to be moved by hand in X,Y and θ directions to facilitate measurement at any desired point on the sample surface. The X and Y coordinates translation facilitates measurement on a rectangular or grid pattern; zero (0) to 2 inch left-to-right translation (X direction), 1 inch in the -Y direction from center, and 1/32 inch in the +Y direction. Total rotational travel (θ direction) is 0° to 360°. If the white plastic retainers are removed from the table, translation in the +Y direction is increased to 1 inch.

L116HXY5 - This stage is identical to the L116HXY6 stage except that this table will allow measurements on samples 5 inches in diameter or less. The front-to-back translation (Y direction) is ±1 inch from the center.

MICROMETER POSITIONING STAGES

L116MXY6 - This stage is identical to the L116HXY6 stage except micrometer thimbles are added to allow fine motion translation in the X and Y directions to facilitate positioning within rectangular scribe lines. One division on the thimble equals 0.001 inch. This stage is especially useful with the Microspot Optics L116MS accessory.

L116MXY5 - This stage is identical to the L116MXY6 stage except that this will allow measurements on sample wafers no greater than 5 inches in diameter.

FINE MOTION HEIGHT ADJUSTMENT L117FM

This feature may be added to any type of sample stage and consists of a rotatable inclined plane acting through a transfer plate and the standard height (vertical position) adjustment to raise or lower the table 0.010 inch maximum (from the mid-position reference) after setting the standard vertical position. One half turn of the knob moves the table 0.010 inch. The knob is at the mid-position when the center line of the reference hole on the knob is at the centerline of the table clamp screw. A clockwise rotation of the knob raises the table (CCW lowers the table). See pages 6-2.1 and 6-2.2 for detailed information.

MICROSPOT OPTICS L116CMS (Gaertner Installed)

This option has a projector optic that reduces the normal 1 mm diameter beam at the sample surface down to 0.015 mm (to measure very small areas) and a receiver optic (for added efficiency). See the table in subsection 1.0 (Specifications) in the "Description" Section of this user manual.

NOTE: *The table in subsection 1.0 (Specifications) shows the dimensions of the laser beam on the* sample with and without the Microspot Optics at different angles of incidence, ϕ.

INTERFACE LRS232

This option enables the user to send or receive serial data via an interface with RS-232C compatible equipment such as a large-scale (host) computer, data terminal and modems. Includes interface cable, modified software and program User Instructions. Contact Gaertner for details on specific data communication specifications.

VIDEO MONITOR L115VM

This option allows the ease of monitoring a wafer pattern display on a CRT screen in addition to the standard viewing microscope. An M/T switch is usually mounted on the front of the Sample Monitor Assembly when a video monitor is included with an ellipsometer.

WAFER HANDLER L116WH

Model L116WH Wafer Handler permits unattended automatic measurement of up to 25 wafers from a cassette. The randon-access indexer on the Wafer Handler is ultra clean with the mechanism fully contained within the housing so that there are no moving parts near the wafer. The "frog-leg" type of motion of the arm is simple, clean and gentle.

200 mm (7.9 inches diameter) SAMPLE TABLE

This larger table is for 3" (76 mm), 100 mm, 125 mm, 150 mm and 200 mm wafers for film measurements. See Figure 6-1.1 for a top view of this table.

NOTE: If an ellipsometer has a 200 mm diameter table and the Microspot Optics, it is not possible to move this table out of the two arms so that they can be set at a 90° incidence angle; thus ignore any instructions that call for setting the arms at 90°.

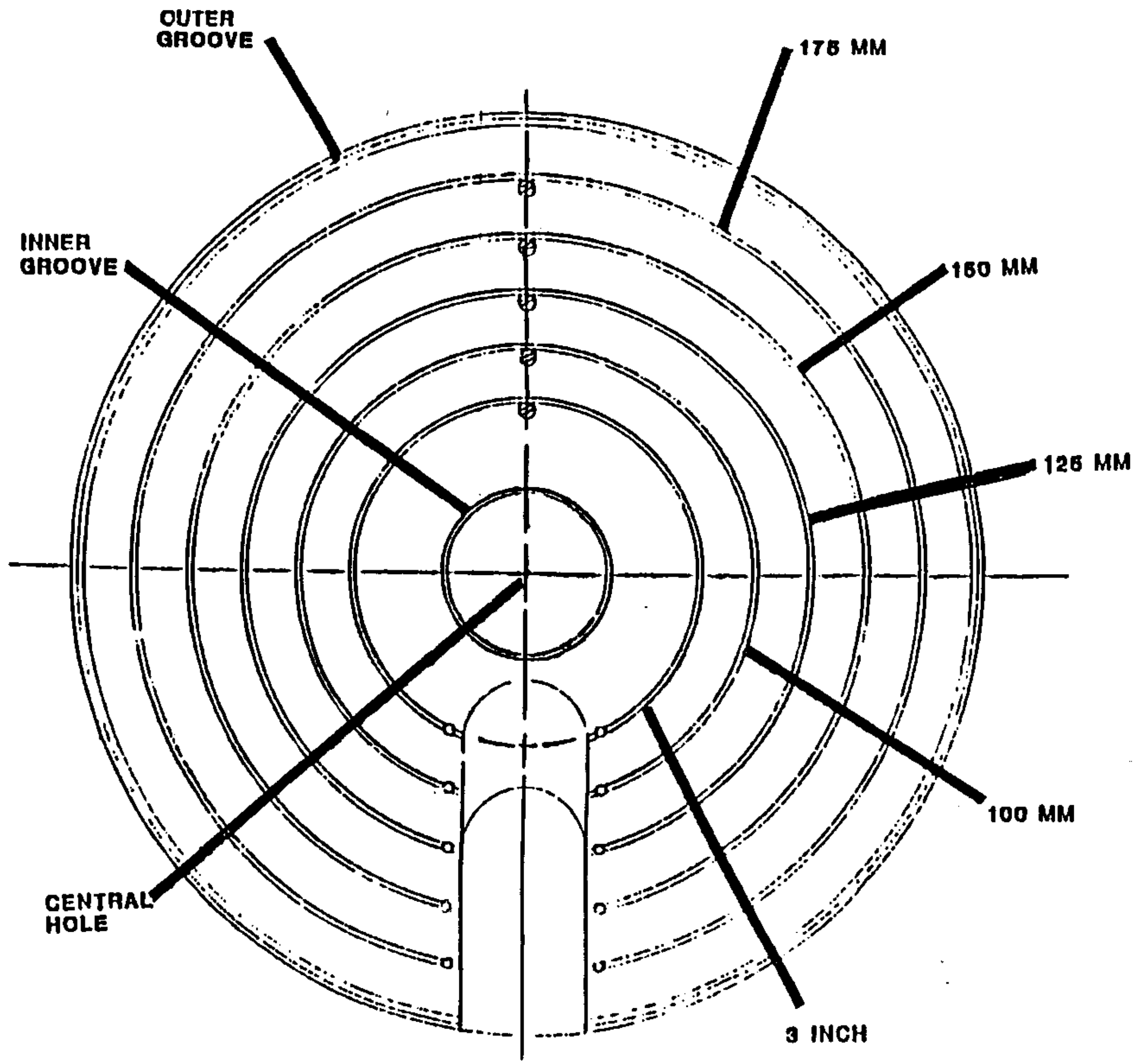


Figure 6-1.1 This is a top view of the 200 mm (7.9 inches) diameter sample table.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 TROUBLE ANALYSIS

Gaertner ellipsometers should have long-life, trouble-free operation. In the event of a malfunction, symptoms are readily traceable by the use of diagnostic software and intermediate check points. This should be done by qualified service personnel. Fault isolation involves troubleshooting to isolate the cause of failure only to a component or assembly readily removable for further fault isolation and repair or replacement. During automatic operation, a malfunction is usually shown by no measurement data, inconsistent measurements, or even operator-induced errors.

1.1 Measurement System

During automatic operation, the four-detector-voltages of the StokesMeter are amplified and applied to the circuitry of the Sample and Hold Board. See Figure 7-1. Digital control pulses are coupled with timing circuitry to provide a trigger for the Sample and Hold system. This allows all four voltages to be sampled simultaneously. The sampled voltage levels are adjusted by computer-controlled auto-gain circuitry to fall within a 1V - 9V range. Finally, the analog signals are converted to digital signals and are read by the A/D Computer Interface Card.

Computer analysis of the measured data yields the desired ellipsometric measurement.

1.2 Troubleshooting

Table 7-1, starting on page 7-3, lists the symptoms of malfunction, possible cause and corresponding actions relative to fault isolation. The symptoms are listed in a sequence generally reflecting the operating procedure, i.e., premeasurement setup and measurement procedure. As a troubleshooting guide, the listing assumes all dc power supplies are operative and no discontinuity in wiring.

NOTE

The A/D Circuit Board must be initialized by the batch file INIT.BAT. INIT should be the last entry in the AUTOEXEC.BAT file on the program disc.

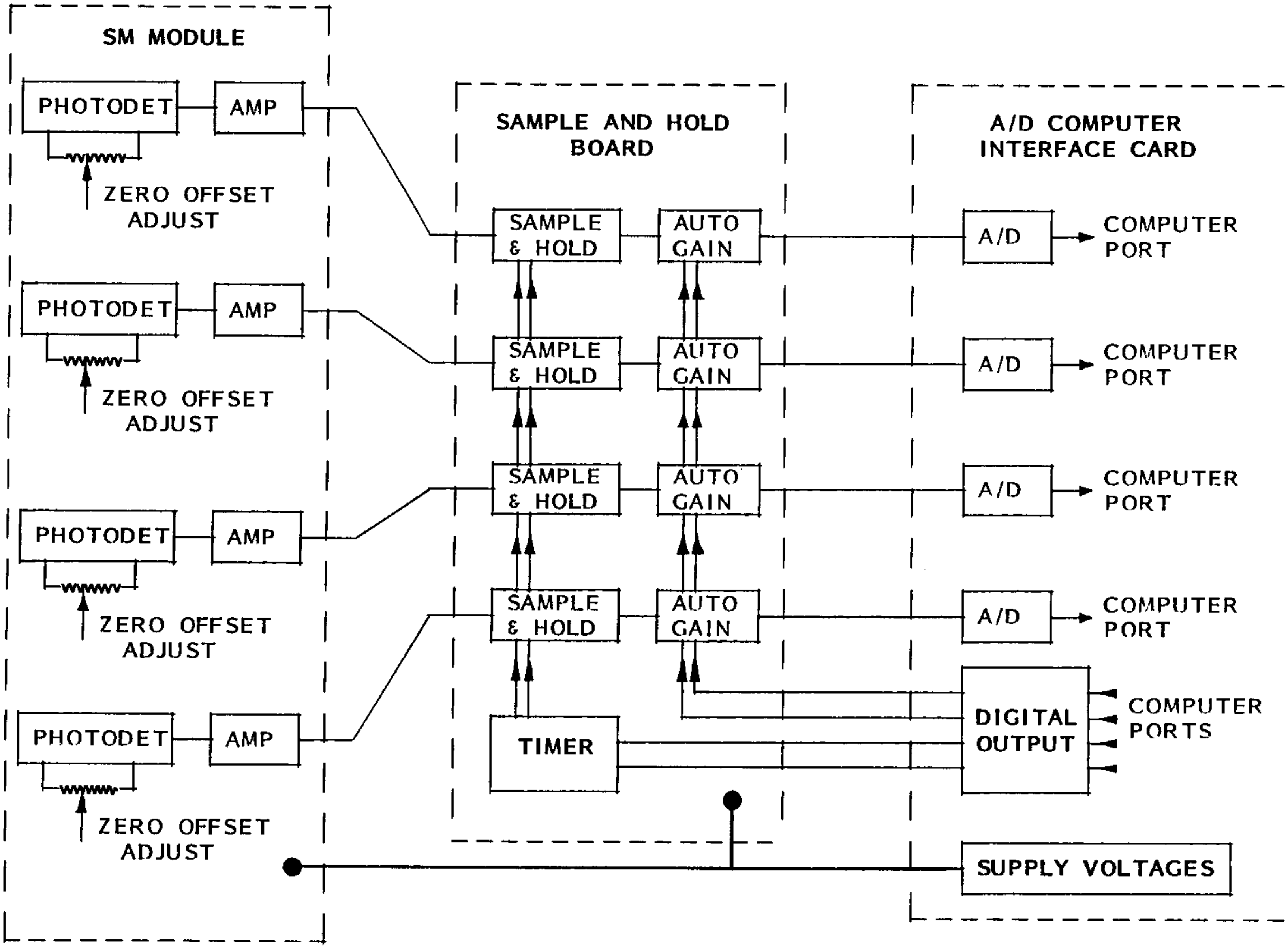


Figure 7-1 Measurement System Functional Diagram.

TABLE 7-1. TROUBLESHOOTING GUIDE

SYMPTOM	POSSIBLE CAUSE	FAULT ISOLATION
No power to the ellipsometer (Key switch at ON)	No line voltage	Verify that the ellipsometer power cord is seated in an ac power outlet.
		Check the fuses; replace if defective. They are .75A, slow blow (Figure 7-6).
Emission indicator does not illuminate at power turn-on	Lamp burned out	Replace the lamp. If the problem is still present, the instrument power supply transformer or monitor assembly transformer may be at fault.
No light is emitted from the polarizer aperture	The Beam attenuator is closed	Check the position of the attenuator; if it is closed, PULL TO OPEN IT.
	Defective laser or laser power supply	Needs the replacement/alignment of a laser or removal of instrument power supply for repair (contact Gaertner).

TABLE 7-1. TROUBLESHOOTING GUIDE (continued)

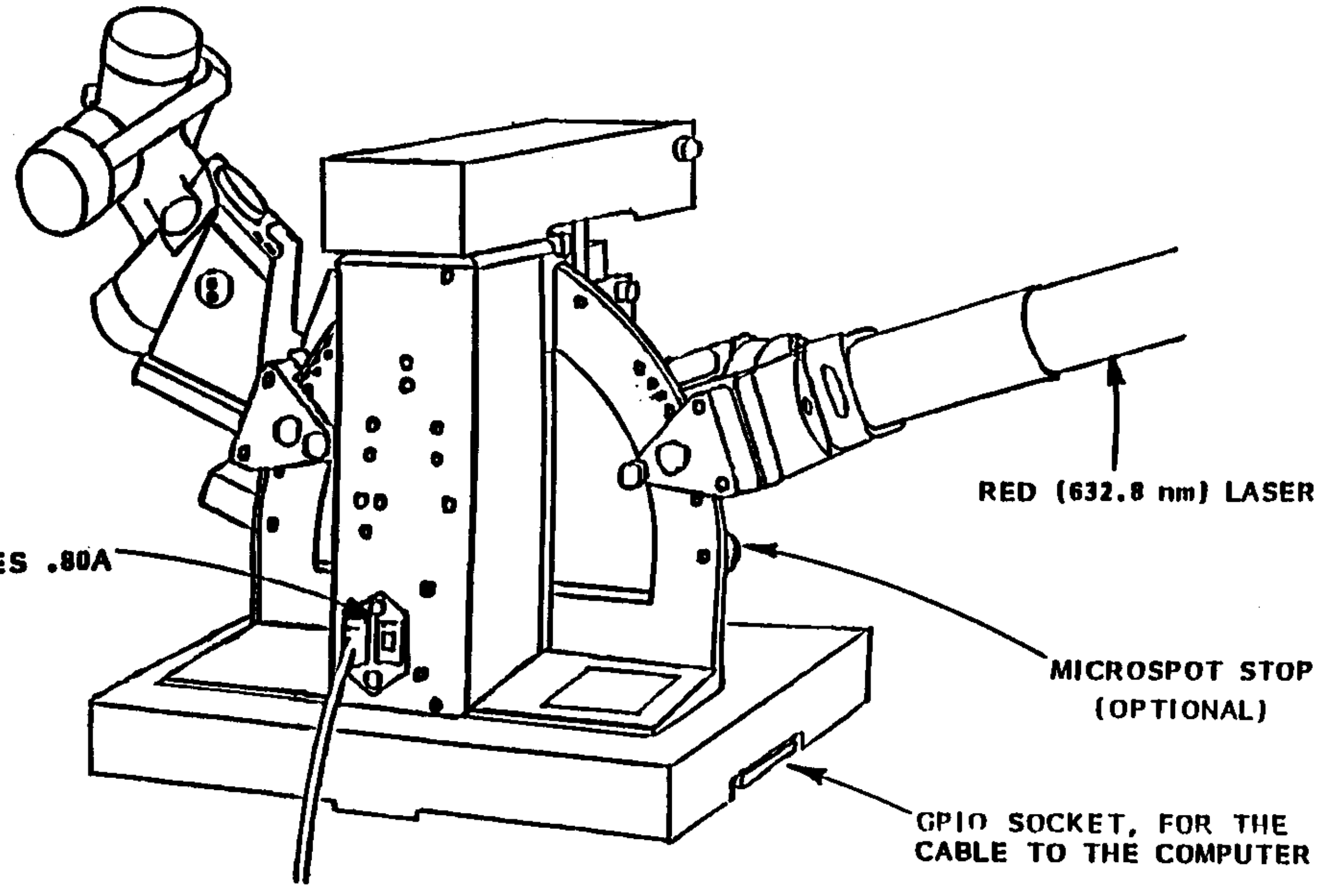
SYMPTOM	POSSIBLE CAUSE	FAULT ISOLATION
Inconsistent or inaccurate measurements	Failure to use TableMax program prior to measurement (See Section 3)	Upon exiting the TMax program option, the autoranging-gain circuitry is activated. Hence, TMax must be run whenever P, PHI, or the sample is changed.
	Inaccurate Polarizer Azimuth P	Observe the Polarizer drum scale. Ensure that it matches that which is displayed by the computer program.
	Inaccurate incidence angle PHI	Ensure that the angle of both arms match that which is displayed by the computer program.
		Check the detents and tighten the knobs.
	Sample table misalignment	Check the tilt and table height (TMAX).

TABLE 7-1. TROUBLESHOOTING GUIDE (Continued)

SYMPTOM	POSSIBLE CAUSE	FAULT ISOLATION
Inconsistent or inaccurate measurements (continued)	Photdetector dark-current (dc offset) has changed	Dark-current may be measured using the diagnostic program, DIAG. See section 2.
	Photodiode or circuit failure	This may be verified by observing the measured detector voltages using the program DIAG. See section 2. This problem should be addressed by SERVICE PERSONNEL ONLY!
	Optical Misalignment	Alignment may be verified by the use of the program DIAG. See section 2. DO NOT ATTEMPT TO REALIGN THE INSTRUMENT. This problem should be addressed by SERVICE PERSONNEL ONLY!

CAUTION (For 90° Angle of Incidence)*

If the ellipsometer has Microspot Optics, turn the table so that its notch (lifting slot) is under the analyzer arm. Move the table to the left and down so that neither Microspot Optic will touch the table when the arms are at 90°.



*The optional 200 mm dia. table cannot be moved out of the way of the optional Microspot Optics. Thus, the arms cannot be set at 90° with both options.

Figure 7-6 Rear and left view of the L116S Ellipsometer.

2.0 DIAGNOSTICS

A diagnostic program named DIAG.EXE has been supplied with this unit. This program is used as a troubleshooting aid. Upon running DIAG, the menu illustrated by Figure 7-3 will be displayed.

2.1 Photodetector Zero Offset Adjustment

Selection F2 of the Main Menu yields the display illustrated by Figure 7-4. Photodetector Zero Offset may be checked by simply closing the laser shutter. All voltages should then read 0.000. If any voltage is non-zero, press the F1 key followed by ENTER to measure the dark-current. This information is stored in a file named DARK_CUR.DAT.

2.2 Automatic Amplifier Gain Check

The proper operation of the autoranging-gain circuitry can be verified by using the Range (F2) option shown in Figure 7-4. Note that the laser shutter should be open, and that no change will occur if the four-detector-voltage average is within the 1V - 9V range.

2.3 Optical Alignment Check

Selection of F1 of the Main Menu yields the display illustrated by Figure 7-5. Alignment is indicated by the centering of the crosshairs (+) within the target area.

NOTE

The dark-current should be measured (subsection 2.2) prior to the use of this option.

CAUTION

DO NOT ATTEMPT TO ADJUST THE ALIGNMENT OF THIS INSTRUMENT. THIS WILL CAUSE A CALIBRATION FAILURE. CONSULT GAERTNER ABOUT ALIGNMENT PROBLEMS.

THE STOKESMETER

***** MAIN MENU *****

F1 - ALIGNMENT DISPLAY

F2 - TEST AND DISPLAY A-D BOARD OUTPUTS

F3 - EXIT THIS PROGRAM

Gaertner Scientific Corporation - ©1992 Ver. 1.0

Figure 7-3 Diagnostic Program Main Menu.

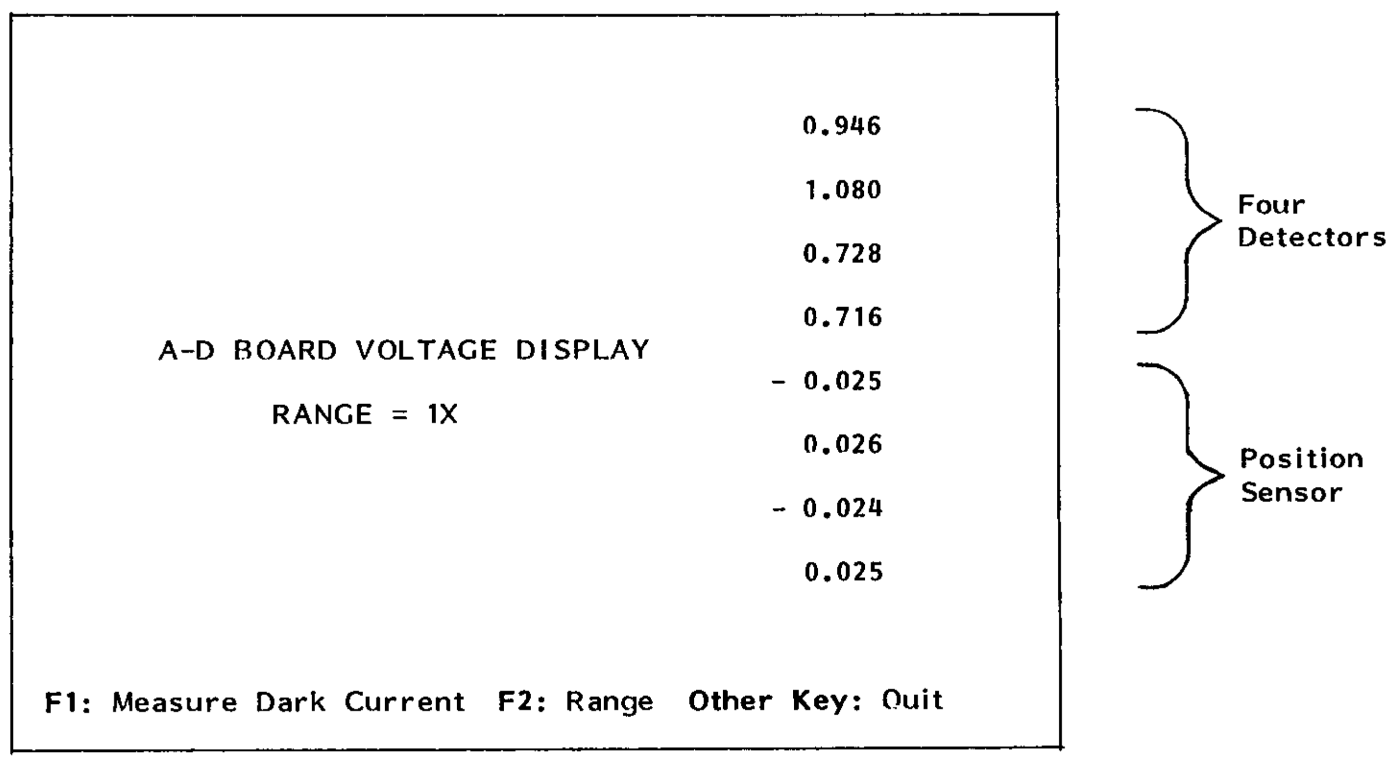


Figure 7-4 Test and Display A-D Board Outputs (DIAG).

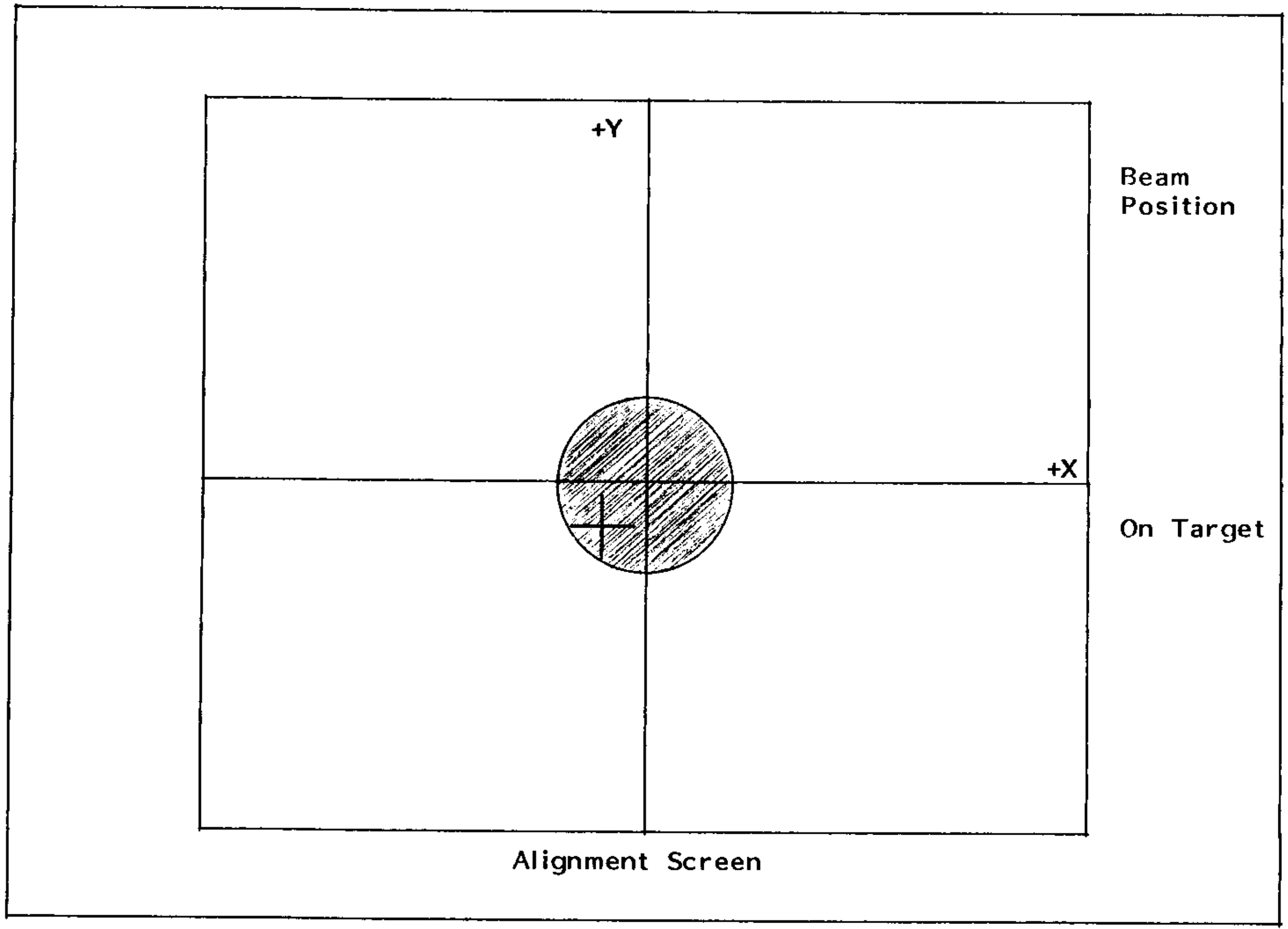


Figure 7-5 Alignment Display (DIAG).